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TEACHING GEOMETRY AND LOGIC

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To judge by the number of articles that have appeared recently, one of the most important topics of the day is that of teaching more logic in geometry classes. Many writers are trying to convince us that the most important (some folks say *only*) reason for teaching geometry is to impart some knowledge of reasoning. Only occasionally can we now find a writer who is willing to admit that the teaching of geometry has many objectives and that learning logic is not the most important.[1]

There are many interesting questions to consider. For example,

1. Is the nonmathematical material introduced because it is important or because the geometry is unimportant? From some of the arguments that we hear we get the impression that the new material was introduced because some tests show that pupils do not learn or do not retain much geometry and it is hoped (we have no evidence) that the new material can be learned or can be retained.

2. Is a study of geometry necessary or sufficient or both for learning how to think clearly? In other words, could the objectives be reached without bothering about geometry at all; and after we have studied geometry have we included all types of reasoning which are used in nonmathematical material? Or, what further work (either in logic or in something else) should

[1] E. R. Beslich, "The Nature and Place of Objectives in Teaching Geometry," *The Mathematics Teacher*, Nov. 1938.

high schools offer in order that pupils may learn to think clearly?

3. Should the nonmathematical material be used as an introduction to geometry or should the geometry serve as an introduction to the work in logic?

4. If the main object is to teach logical thinking and only as much geometry as is necessary to illustrate the logic, is it necessary to devote an entire year to the work, or can the objectives be attained in less time? But if the objective is to learn some geometry and also some logic, can the logic be interwoven into a course in geometry so that in one year's time the pupil will learn something of both? If we must teach less geometry, what can be eliminated?

These questions can all be reduced to: What shall we teach? How much time shall we devote to the work? And what methods are the most effective?

Obviously in a field as new as this, it will be many years before we can arrive at any answer to these questions. We can merely study the reports of experiments and attempt to help others by reporting our experiences. Hence I shall begin by referring to Fawcett's experiment as reported in his book, "The Nature of Proof."[2]

Fawcett's class met four times a week for two years. (68 weeks. The four periods included all needed study time since no outside preparation was required of the pupils.) This news will be a disappointment to teachers who would like to repeat Fawcett's experiment but whose curriculum will allow only one year. Further, three-fifths of Fawcett's pupils were juniors at the start of the work since the ninth and tenth grades were devoted to algebra, and the eleventh and twelfth grades to geometry and the nature of proof. These facts may easily be overlooked since we are accustomed to associating "plane geometry" with a course spread over one year and offered in the tenth grade.

Fawcett began by using nonmathematical material for four weeks. From this introduction the pupils learned the need for exact definitions and that a change in a definition may change the conclusion. The class then began some geometric work using material from space as well as in a plane. After the adoption of some definitions and assumptions the class studied the implications to which these led. The notion of converse developed

[2] Bureau of Publications, Columbia University, $1.75.

from a study of angles related to parallel lines. The inductive process of reasoning was introduced, not through nonmathematical material, but by studying the exterior angles of polygons; examples of inductive material in other fields were then studied. This was followed by a further study of the need for recognizing the assumptions in nonmathematical material. At the end of the first year the pupils' knowledge of geometry was tested by an examination which covered the material of Book One.

I assume that the second year was devoted to Books Two to Five and a continuation of the study of the nature of proof. At the end of the second year the class took the Every Pupil Test conducted by the Ohio State Department of Education and made a higher score than those pupils in other schools who had studied geometry in the traditional manner.

Next I shall discuss my own experiences based on teaching at least two classes of geometry each year for more than twenty years. These are tenth grade pupils and the class meets five times a week. I can hardly be considered a biased party as it was through my efforts that one of the earliest articles dealing with this question was published thirteen years ago.[3] The ideas were considered so strange at the time that the editor would allow only two pages for the article.

After trying both methods I now prefer to begin the course in geometry in the traditional manner. When we reach our first important general statement such as "Vertical Angles Are Equal" we discuss how a general statement is used and the three steps of a syllogism. I have never favored dodging useful words merely because they are new or may later be misused, and so we use the customary terminology: major premise, minor premise, and conclusion. Many illustrations of syllogistic reasoning with nonmathematical material are used, such as

Write in syllogistic form the arguments:

(a) Starch contains carbon since it is an organic substance.

(b) The 11:30 train does not stop here; it is an express.

We also study exercises in which there is a wrong major premise, or a wrong minor premise, or a wrong conclusion; also exercises in which one of the three steps is missing and must be supplied.

As soon as we begin using generalizations to prove exercises

[3] F. L. Abbott, "The Three Step Method of Teaching Geometry," SCHOOL SCIENCE AND MATHEMATICS, April, 1925.

we learn that a proof means: Find a syllogism of which your conclusion is the third step. This approach eliminates any need of studying optical illusions. Of course we can see that the thing we are trying to prove is true. We would not be so stupid as to try proving something that did not look true. In fact, we try to prove only statements which we can see are true. The pupil's attitude is: AB looks equal to CD. Can I find a syllogism of which $AB=CD$ is the conclusion? The old attitude "Why should I prove it when I can see it?" is replaced by "Because I can see it, I should be able to show that it is an inevitable consequence of some previously accepted generalization."

Arguments involving indirect proofs arise as soon as we begin the topic of parallel lines. Non geometric material is so abundant that it does not need discussion here. We spend about one day with it, either preceding or following the geometric work.

Some time, usually after indirect proofs have been studied, a pupil may say in his proof of some exercise "If the angles were not equal, the triangle would not be isosceles" or "If the angles are not right angles, the lines would not be perpendicular." This is my clew to call attention to the wording of the statement and to introduce the notion of the contrapositive of a statement. After an examination of a number of examples we agree that a proposition and its contrapositive are either both true or both false. It is also important to see that in the proof of a proposition we must not assume the contrapositive since this is equivalent to assuming what is to be proved.

About the seventh week we meet our first converse, and the question then naturally arises: What is the contrapositive of the converse? We have usually called this the *opposite* theorem but after reading Lazar's articles[4] I have decided to use the word *inverse*. Since we have previously agreed that a theorem and its contrapositive are either both true or both false, we must now admit that the converse and inverse are either both true or both false. (Incidentally, note that the previous sentence is a good example of how a conclusion is related to a previous assumption.) We then spend a day investigating a proposition and its three related propositions. The geometric applications at this stage are few but will increase during the year. For the non-mathematical material we use such exercises as

When a gasoline company advertises "Our Gasoline Is Yel-

[4] *The Mathematics Teacher*, April 1938, p. 157.

low" what general proposition does it want you to think of? What are the three related propositions? Which do you think are true? Which one does the company want you to believe? Why does it not say so in the first place?

The contrapositive, converse, and inverse of statements are particularly useful when we discuss the meaning of the words *necessary* and *sufficient*. There is no fixed time in the course for introducing these words and the related discussion. I wait until an error in a proof by some pupil shows a misunderstanding of the words and presents a reason for analyzing them.

When the unit on parallelograms has been finished, usually about the tenth week, the pupil has learned what a deductive proof is and the meaning of a postulational system. He might describe them as follows: "We begin with undefined terms and agree to certain definitions and assumptions. These lead to certain conclusions. From these we can deduce other conclusions, which lead to more conclusions, and so forth. A deductive proof is a succession of syllogisms which lead from the data to the conclusions." The pupil has now been *sensitized*, we may say, to certain procedures and habits of thought.

In articles discussing clear thinking there is frequent mention of the idea that a changed definition may change the conclusions and that if we accept certain assumptions we must accept the conclusions that follow from them. The pupils easily grasp the idea that if you change the definition of a "home run" you thereby change the score; in fact, this idea is so obvious that the pupils wonder why it should be discussed at all. Likewise, the fact that our geometric theorems depends on postulates evokes no great surprise because the postulates are such that the pupil has no reason to doubt them. To make the pupil appreciate that conclusions depend on postulates we need to have situations in which different postulates can be considered. An example like "Whether or not John should be permitted to drive a car depends on whether the law says 16 or 17 is the proper age for driving" will not meet this need because in such examples the postulate is not a matter of truth but of opinion. And here again it seems trivial, to the pupil, to say that your conclusion depends on your opinion; one might as well say that what you think depends on what you think.

In order that such work may seem less like quibbling over trifles I prefer to discuss definitions from the point of view of what makes a definition a *good* one, and to discuss assumptions

by asking what assumptions are needed to make a certain conclusion a correct one. For example,

Supply the missing major premise in the arguments:

(a) The dial telephone saves labor. The dial telephone is a benefit to society.

(b) Bill is a life guard at the beach. He must be a good swimmer.

When stated in this way the pupil sees that here is the same question which arises in his geometry: What theorem can I use to arrive at my conclusion? Hence the geometry and the nonmathematical material assist each other. The equivalent of a few days scattered over many weeks is allotted to such work.

In several articles there are illustrations of how a pupil who has learned geometric proofs can apply these ideas to proving some nonmathematical statement, such as proving that you should buy a certain article or abide by some social convention. The proofs, however, are not like the proofs which the pupil uses in his geometric work. In fact, some appear to be so different that they would be detrimental to the pupil's work in geometry. I shall illustrate how I think a proof of a nonmathematical statement should appear.

An advertisement for a fountain pen said that its ink barrel was made of transparent material so that the amount of ink in it was visible. Hence it would not become dry suddenly and thus annoy or interrupt your thoughts when you were about to write some brilliant idea.

The argument would be:

1. In the X pen the ink supply is visible.	Given.
2. The X pen does not become dry suddenly.	If the ink supply is visible, the pen will not become dry suddenly.
3. The X pen will not harass the brain.	If a pen does not become dry suddenly, it will not harass the brain.
4. I should buy the X pen.	If a pen does not harass the brain, I should buy it.

Note the theorems in the right hand column. The hypothesis of the first is the given data. Its conclusion is the hypothesis of the next theorem. Its conclusion is the hypothesis of the next theorem, and so on. The conclusion of the final theorem is the conclusion of the argument. The importance of this form has been admirably described by Sitomer in an article.[5] But the proofs shown in many articles do not follow this form, and hence they cannot seem to the pupil to be applications of what he

[5] Harry Sitomer, "If- Then in Plane Geometry," *The Mathematics Teacher*, Nov. 1938, p. 326.

learns in geometry. To allow a disconnected jumble of statements to be called a proof will undo the work the teacher is trying to accomplish. The examples of proofs of scientific statements follow the geometric pattern more closely; but such work is done so well in the science classes that there is no need for the geometry teacher to repeat it.

Sometime before the first semester is ended I aim to spend a few days discussing the deductive and inductive methods of reasoning and the scientific method of problem solving. Although Dowling's "An Introduction to the Teaching of Science" is a textbook for teachers, I find that pages 83–93 are easily understood by pupils. We study how the fundamental steps (a felt difficulty, collecting of information, making of tenable hypotheses, and so on) are applicable to algebraic, geometric, and then to nonmathematical problems. We aim not merely to use geometry to teach clear thinking, but to use clear thinking to help us in geometry.

With the beginning of the second semester the usual work in Book Three necessitates a review of some parts of algebra. When the pupil is unable to solve $ax+bx=c$ we consider the simpler equation $3x+4x=5$; if the pupil cannot solve $\pi r^2=60$ we consider the simpler equation $5x^2=60$. In other words, if a problem puzzles you, try to get an inspiration by attacking a simpler problem. This introduces the topic of reasoning by analogy. We illustrate and apply the idea to geometric, algebraic, and other problems. About two days are spent on nonmathematical material. In particular we discuss the requirements for a good analogy and the dangers of a poor analogy. In the last six years we have had abundant material discussing governmental policies which have been tried previously in history. Due to lack of time we cannot do more than state the problems, decide what data we need, and then suggest that the problem be studied in history and social science classes.

During the remainder of the semester the nonmathematical material is centered around the topic: Mistakes in Reasoning. For this work I have found the chapters on Pitfalls in Reasoning in Lyman's "The Mind at Work" very useful; the library copies are put on reserve and made required reading. Half an hour is set aside each week for six weeks; each discussion is devoted to certain types of errors, and the pupil is required to gather or make examples of the types illustrated in the previous lesson. Among the types studied are:

Arguing in a circle. Generalizations from insufficient data. Misleading analogies. Assuming the converse or inverse. Using a wrong major or minor premise. Using poor authorities. Non-causal relations. Ad Hominem arguments. Pooh-poohing the question. Irrelevant material. Appeals to prejudice. Ambiguous words. Failure to consider all possibilities in an indirect argument. Inconsistent statements.

Geometric examples can be found for some but not for all of these errors. The pupil who assumes the thing he is trying to prove is "arguing in a circle" or "begging the question." Assuming that a helping line will pass through certain points is an error that is more difficult to classify. As far as possible we point out geometric analogies so as to improve our geometric work.

Let us now return to one of the questions raised at the beginning: Is the study of geometry sufficient to accomplish our purpose?

It seems to be a firmly entrenched notion that geometry has failed to teach clear thinking unless the pupil has been made less gullible, less inclined to believe all that he reads, and more insistent on a reason for every statement that he hears. I believe that some of the expounders of this idea have failed to distinguish between *logic* and *truth*. For example, consider the syllogism

1. All odd numbers end in the figure 3.
2. 68 is an odd number.
3. 68 ends in the figure 3.

The logic is, I think, correct. But are the statements true?

For another example, suppose I am considering the purchase of a hot water heater. A dealer may say to me "The Hotsy Heater will last longer because it has copper coils." His proof is based on the assumption: Copper coils last longer than other coils. I can perceive that his logic is correct; but logic alone will not tell me if the conclusion is *true*. I must still consult an engineering research staff to avoid being considered gullible. When the items in a hypothesis are necessary but not sufficient we must add items to the hypothesis. In this case, if we aim to make the pupils "foolproof" we must add to our geometry courses not only a study of logic but some lessons on how to determine when a statement is true. Perhaps it would be advisable to follow our year's work in geometry with a new course "Truth, and How to Find It" or "The Nature of Truth."

There are still other reasons why geometry and the inter-

woven logic is not sufficient. In geometry we have propositions like:

If A is true, then X is true.

In real life the propositions are like:

If A is true, then X is true; if B is true, X is not true.

But, in real life, we may know whether A or B is true. Thus there are many reasons why I should buy a Hotsy Heater and also many reasons why I should not. My problem is to weigh the various reasons and then come to a conclusion. Can we find analogies of this sitution in geometry? Some writers are expecting pupils to learn from geometry things that geometry does not teach.

On several occasions, when time has permitted, I have devoted one week at the close of the year's work to the question of *logic versus truth*. We based the work on "Propaganda. How to Recognize It and Deal with It."[6] This gave us a very good opportunity to begin in a logical manner by deciding on a definition for *propaganda*, and then applying the lessons on mistakes in reasoning. The final opinion of the class has always been that it is easier to detect errors in reasoning than it is to decide if a conclusion is true. The pupils also felt that the publishers of this pamphlet were misleading the public because they do not tell you how to recognize propaganda and do not tell you how to deal with it. The pupils wanted some way of telling whether or not a statement is true, and some way of telling when you have *all* the truth.

I do not mean to imply that, because geometry is insufficient, we should cease teaching it or not profit by what it does teach. I merely call attention to some of its deficiencies so that we may some day obtain a solution of our problem. In the meantime geometry should not be blamed for not teaching what it cannot teach. A class in French is not necessarily a failure because pupils learn no Latin in it.

In another article I shall discuss what contractions in the geometric material were necessary to allow time for the work I have described.

[6] Published by Institute for Propaganda Analysis, 132 Morningside Drive, New York.

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ADDING INTEREST TO THE ELEMENTARY SCIENCE CLASSROOM

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[EDITOR'S NOTE: SCHOOL SCIENCE AND MATHEMATICS has planned a series of four articles of practical use and interest to elementary school teachers and especially to those interested in science. If these four articles are saved and arranged in a notebook they will make a useful and practical reference book.

The first of these four articles has been written by Dorothy V. Phipps who has been the advisor and coordinator of the Science Demonstration Centers of the Chicago Public Schools. She has taught intermediate, junior and senior high school science and conducts courses in the Chicago Teachers College related to the teaching of science in the elementary grades. The second article of this series will appear in the April issue of SCHOOL SCIENCE AND MATHEMATICS and will deal with the practical aspects of the care and handling of pets in the elementary school classroom. —D.W.R.]

Let us pause a moment in the hurry of everyday science teaching and stop to consider the effect of our classroom upon our pupils and ourselves. Is our room a cheery place, not overcrowded, yet full of interesting things? Are our children anxious to come to the room in their spare moments because they can't wait to see how the fishes, so recently removed from their small lake home, are enjoying aquarium life? Are collections of rocks, or shells, or even bits of different kinds of wood, brought in by eager youngsters who are anxious to put their precious findings in some safe place for the other children to admire and inquire about? Are there growing plants to add a bit of color and an atmosphere of outdoor life? Do the children care for them, and talk about the way they turn their leaves toward the light or why a plant will grow very tall on one window sill and not so tall on another? A teacher who can answer these questions in the affirmative is making science a vital subject to her pupils, so vital in fact that it permeates the atmosphere of the room; the room, on the other hand, sending back its stimulation for further interest to its occupants.

While it is often easier to make a departmental science room present an interesting appearance because of the availability of more apparatus and because it holds only science classes, any classroom may have a real science atmosphere. How can this be brought about? The following suggestions are only a few of the numerous ways this can be done.

I. Growing Plants in the Classroom

Plants may be grown in window boxes, flower pots, enameled coffee cans, or in hanging baskets. Seeds may be planted in paraffined paper cups, the cups to be made by the children and paraffined by the teacher. A painted wooden cheese box resting on spools makes a fine garden spot. Dwarf marigolds will flower when grown from seeds. Radishes, beans, and corn make good vegetable gardens. Narcissus bulbs, planted among small pebbles with plenty of water and kept in the dark until the roots and leaves are well developed, then placed in the light, need about six weeks to flower. The leafy end of carrots which have been cut in half cross-wise may be placed in a bowl and make a splendid leafy plant. Horseradish and turnip roots cut across so that they can stand in a shallow bowl, leafy end up also make attractive plants. Even north rooms may have growing plants by using such plants as begonias, sansevieria, phylodendron and ivy. The more pupil activity involved in bringing in, arranging and caring for the plants, the better. This may be used as a beginning for the study of the way in which plants grow; the life needs of plants; their reactions to water, light, heat, and their decorative value for the home.

II. The Science Museum

This is a place where pupils may bring collections for more or less permanent display. A series of open shelves, a cabinet with an electric light, or only a box with a glass door and lighting arrangements, may be used to hold the articles. Cocoons, insects, twigs in different stages of development, shells from local regions, rocks, fossils, all make interesting collections. The pupils should develop this museum not only by bringing in objects but also by finding out interesting things about them and labelling them. An information card may accompany each object.

III. The Science Table or Corner

Pupils may bring in varied types of science materials or work out a table exhibit on one definite subject. Sand may be sprinkled on the table, shells arranged on it, and a background painted on paper and tacked to a board of soft wood standing on the back of the table against the wall. This makes a simple diorama of a beach or shore. Pictures, books, graphs, and charts giving information about the material displayed add great value

to this type of exhibit. The subject of the science table or corner may be any one in which the pupils are interested. Frequent changing of materials will keep up the interest. Stimulating questions attached to the exhibits will add interest if the answers are discussed during the science club period.

IV. A Science Bulletin Board

Children are interested in knowing that problems which they are studying are also being studied by scientists. The bulletin board is one way of bringing this information to them. It may be made of cork board, soft linoleum, or wall board painted and framed. Pictures, clippings, drawings, graphs, announcements, radio schedules, the time of rising and setting of the sun, moon, evening and morning "stars," are a few of the possibilities offered.

It should be placed in a good light and low enough to be easily read. All materials should be carefully checked for accuracy by the teacher although a small committee of pupils may have charge of it. The committee should be changed often.

V. The Classroom Aquarium

1. Where to put the aquarium. An aquarium can be placed on a table near the windows but not so close that direct sunlight will overheat the water. Perhaps the table will be sufficiently large for vivaria in addition, although it is best not to overcrowd or to have too many different ideas suggested in such a small space. If the table is a long one, a grouping of environmental succession studies may be shown such as, an aquarium to show water habits, vivaria that show a swamp, bog, moist woodland, woodland vivaria, and also a desert scene. Several habitats may be combined in one vivarium, as we shall see later. You say you have no room for an extra table? This need not stop you. Often the window sills are sufficiently wide to support an aquarium. If the light is too strong a cardboard may be placed over the top and along the sides of the aquarium receiving too much sunlight, or the glass on the sides concerned may be painted on the outside with green or blue paint which will blend with the habitat within. A final covering with aluminum or white paint will reflect the light. Be careful not to cover too much of the area as most plants and animals need light. It is only the direct sunlight from which we must shield some forms

primarily because the aquarium walls retain too much heat or because plant growth is stimulated too much. If you have neither table nor wide window sills and can't have boards placed over the sills and braced below, then you must resort to something else. Sometimes there are more desks than pupils in the room. If so, enameled boards or boards covered with oil cloth may be placed upon the desks and used as table tops. This allows the children to sit in the seats while making observations.

2. Building a balanced aquarium. Choose a large container. A five or six gallon aquarium is best. It is large enough for several animals and small enough to be conveniently handled. It should be of rectangular type, the round bowl type being difficult to observe. Be sure it is well built and strong with metal bracings at the corners. If the glass becomes loose with use, purchase aquarium cement at a biological supply house or pet shop, remove the contents of the aquarium, dry the aquarium thoroughly and apply the cement on the outside junctures. Fill the aquarium with water to press the glass into place and later cement the inside after again removing the water and drying.

If an aquarium is not available, a large five gallon glass water container, large coffee or candy bottle may be used providing the top is cut off to make the sides straight. This can easily be done in a hardware store which has glass cutting equipment. Or a large deep pan can be used in an emergency. While the latter is not attractive and observations must be made from above, still it is better than nothing.

a) Preparing the container. When the container has been chosen you are ready to start. If the container is a new one, clean it well with soap and water, and dry after being sure that all the soap has been removed. If it has been used before, it should be cleaned and a strong salt solution allowed to remain in it for several hours.

Wash some aquarium sand until all of the dirt and sediment which would cloud the water has been removed. One method of doing this is by putting the sand in a jar, mixing with water and allowing it to settle. Remove the dirty water from the top. Do this until the water becomes clear. If the sand has been used in an aquarium having held infected fish or has been taken from a stream, heat it in a pan in the oven at a high temperature for half an hour or boil it in water for fifteen minutes.

When the sand is clean and free from infectious fungi place it evenly on the bottom of the aquarium. Cover it with a paper

and gently pour water on it to a depth of several inches. The paper keeps the water from stirring up the sand.

b) Selecting plants to use. Remove the paper and add the plants. Vallisneria, sagittaria, or ludwigia if used should have their roots firmly embedded in the sand. If anachoris, cabomba, or myriophyllium are used they should have the ends weighted by tying to a small stone or other weight which is then embedded in the sand as these are non-rooting plants and will float about unless anchored. It has been suggested that twelve vallisneria plants and two bunches of other plants may be used for a five gallon tank.

When plants are bought at reliable pet shops, florists or biological supply houses, one is less likely to get contaminated plants which will cause destruction of animal life in the aquarium. However, with this method of obtaining the materials the joy of collecting is gone. An excursion to a pond or sluggish stream should furnish all of the water plants needed. These plants should be washed thoroughly and dead leaves removed before replanting. After planting, water should be gradually added until it comes to within several inches of the top. Let stand for several days until the water has become clear and of room temperature. Now it is ready for the animals. Because of the latter, do not use sharp stones or castles with small openings as the fish are likely to injure themselves.

c) Adding the aquarium life. Goldfish may be used. They are easy and inexpensive to purchase. They withstand classroom conditions of uneven temperature very well. However, it is more interesting to have livelier fish and those the children can obtain for themselves. Minnows are among those that may be obtained. Allow about one inch of fish for each gallon of water. It is better to have several small fish than one large one. Snails and a fresh water clam add interest. Begin with only three or four water snails as they reproduce rapidly, laying eggs in small masses on the sides of the aquarium. A newt can also be added if desired but allowance should be made for it when planning on the number of fish and mollusks to be used.

d) Balancing the aquarium. Now place over the top of the aquarium a piece of thick glass cut slightly larger than the size of the aquarium. As the plants (when in the light) use the carbon dioxide given off by the animals to make their own foods and in turn give oxygen back to the water to be used by the animals for respiration, the oxygen carbon-dioxide ratio must be

watched closely. Too many animals for the number of plants will cause oxygen starvation in the animals. The fish will come to the top of the water for more air. If this condition exists add a few more plants until a balance results. It may be that there is insufficient light which also would result in an unbalanced condition as the plants would then be unable to carry on sufficient photosynthesis to supply the necessary oxygen and remove excess carbondioxide.

When the ratio seems to be balanced, nothing further needs to be done except to add a little water of room temperature every few weeks to replace that lost through evaporation. Remove dead leaves from the plants. Do not let too much plant growth accumulate. The snails will usually keep the glass free from algae growth if there is not too much light. Occasionally siphon the debris from the bottom and every few months clean the entire tank and begin again.

e) What children learn from the aquarium. Children may learn from participating in building and watching a balanced aquarium that (1) animals give off carbon dioxide that plants use to make their food, (2) that plants give off oxygen during the food making process, (3) that fish, newts, and snails feed upon plants and occasionally like some protein food such as water fleas (daphnia), grated yolk of hard-boiled eggs, and shredded shrimp, (4) that plants can make their own food, and (5) that snails lay eggs in masses on the sides of the aquarium jar and by looking at the eggs everyday through a hand lens a person can see how the egg develops into a baby snail. Many other observations may be made concerning the rooting of water plants, the breathing of the aquarium life, and how the fish and animals breathe, move, sleep, eat, and react towards one another.

VI. The Bog Vivaria

The same container may be used for the vivarium that was used for the balanced aquarium. After it has been well cleaned and dried, place a strip of zinc or glass two inches wide across the width of the container at a distance of from six to eight inches from one end. This strip may be omitted but it helps to hold the soil back. Use aquarium cement at the ends to hold it upright. Place clean washed coarse sand or gravel on the entire bottom. On the smaller side of the partition build the sand upon a base of pebbles to the top of the partition. This side will become a pool. On the other side of the partition place sufficient

sand or gravel so that it will come nearly to the top of the partition. Then add an *acid* bog soil that the children have brought from swampy ground. This should come slightly above the partition and meet the sand from the other side.

Now transfer a few small plants from the swamp or marsh from which the soil came. Plant the roots deeply enough for anchorage to result. Keep the plants moist while transferring them. If sundews, Venus fly trap, and the pitcher plant cannot be found they may be purchased from biological supply houses. Cover the soil and rooted plants with sphagnum moss. Add pond water to the pond area and slope the sand upward to cover the partition. Bring the water level of the land side to the top of the sand layer giving a wet subsoil foundation. Place in the pond of the terrarium a few dragon flies, may fly larvae, water mites, water spiders and water snails obtained from a nearby pond. The pond water which had been added will contain protozoa and perhaps some crustacea. Mosquito larvae may also be added. Flies and other insects may be put in for food for the animals and plants. A fine mesh screening or glass plate should be used as a cover. It will be necessary to renew the animal life often as most of the forms suggested are carnivorous and will prey upon one another.

From observations the children will discover the feeding habits of the animals concerned, the stages in the life cycle of the insects studied, and the relationship of insects to the carnivorous plants.

VII. The Woodland Terrarium

This vivarium represents the true woodland scene. Here again the container mentioned previously may be used. A pond may be made as before or a shallow pan to form a pool may be placed along one side. This may be omitted. Line the inside walls of the container with moss gathered from the woods, the green side toward the outside. This gives a neater appearance to the terrarium. Next add a layer of coarse gravel for drainage, and mix broken bits of charcoal with soil from the woods. On top place leaf mold and humus. Build slopes, hills, valleys around the pool. Here is a chance for the ingenuity of the pupils. Small plants from the woods may now be planted in the soil. Violet, crocus bulbs, wintergreen, and twinflower, are examples. Chinese evergreens and other small plants may be obtained from the florists, but those gathered by the children are

more instructive. Rocks and a couple of lichen covered twigs may be added. Liverworts, ferns and mosses may be planted among them. After the plants have been placed, cover the soil with mosses and liverworts. Add sufficient water to keep the sand layer wet and the loam and humus moist. Cover with a glass plate as in the case of the aquarium. If large drops of water form on the top, there is too much moisture and the cover should be partially removed until only a *slight* fog forms on the glass. Too much moisture may bring about the growth of mildew. The required amount of water will have to be arrived at by observance. Do not add water except by occasionally sprinkling the leaves with an atomizer or adding a few drops with a medicine dropper to the base of the plants. After the plants have become well established, animals may be added. Land snails, slugs, a very small garter snake, cocoons, click and wood boring beetles and other insects, salamanders and frogs are among those animals that will live well under these conditions. The latter cannot be added unless there is a pool. They are likely to burrow down into the moist earth also and upset a neatly made landscape. Replenishing of the animals will be necessary if carnivorous animals are used. The pool may contain animals as suggested for the bog pool. The terrarium should be kept in a light place but direct sunlight avoided. Do not overstock the terrarium with plants or animals.

VIII. The Desert Terrarium

The desert terrarium may be arranged in an aquarium but covered with a wire screen which comes down well over the sides or is weighted so that the animals cannot get out. A depth of several inches of clean sand should be placed upon the bottom of the container. The bottom of the sand should be moist but the top dry. Cacti from the sand dunes or desert regions may be planted. Young Opuntia or prickly pear and Echinocactus or barrel cactus are easy to find. Dig up the roots by digging straight down around the plant as far as necessary so as not to break them. Place a small container of water for the animals down in the sand so that the sides will not be noticed. Some cacti may be planted near the water. Among the animals that may be added are the horned toads, lizards, and insects collected from and found on high beaches or dune areas.

As with the aquarium, the terrarium adds not only interest and attractiveness to the room, but give the pupils an insight into

the environmental requirements, life habits, and care of the plants and animals involved. It is to be hoped that the interest aroused in the classroom may stimulate an interest on the part of the pupils which will carry over into the homes where attractive animal and plant groupings may be enjoyed by all members of the family.

IX. Useful References

Andrews, Mildred, *Gardens in Glass.* New York: A. E. de La Mare Co., $1.50.

Ditmars, R. L. *The Reptiles of North America.* Garden City, N.Y., Doubleday, Doran & Co., $6.50.

Howes, Paul G. *Backyard Explorations.* Garden City, N.Y., Doubleday, Doran & Co., $3.00.

Innes, D. K. *The Modern Aquarium.* Philadelphia: Innes and Son.

Mellen and Lanier. *1001 Questions and Answers About Your Aquarium.* New York: Dodd, Mead and Co.

Morgan, Anne. *The Field Book of Ponds and Streams.* New York: G. P. Putnam's Sons.

Rogers, Julia. *The Shell Book.* Garden City, N.Y., Doubleday, Doran & Co., $6.00.

American Educational Press, Columbus, Ohio. *Indoor Gardens, Booklet 452* (10¢); *The Story of Frogs, Booklet 351* (10¢).

Turtox Service Leaflets (Free to Teachers), General Biological Supply House, Chicago, Illinois. *Leaflet No. 5, Starting and Maintaining a Balanced Fresh-Water Aquarium; Leaflet No. 23, Feeding of Terrarium Animals; Leaflet No. 48, Aquarium Troubles, Their Prevention and and Remedies.*

LEXICON OF GEOLOGIC NAMES

Definitions of the more than 10,000 named stratigraphic units in the United States and Alaska, which are scattered throughout the geologic literature of the past hundred years, have been summarized and brought together in one publication entitled "Lexicon of Geologic Names in the United States," published recently as Bulletin 896 of the Geological Survey, United States Department of the Interior. The definitions were assembled during a period of about 25 years by Miss M. Grace Wilmarth, the compiler of the lexicon, in her capacity of Secretary of the Survey's Committee on Geologic Names.

The lexicon, which is issued in two volumes and contains 2,396 pages, gives the names of stratigraphic units in North America published up to the beginning of 1936. Definitions and redefinitions where necessary are given for units in the United States and Alaska. The names and current age designations of the geologic units of Canada, Mexico, Hawaii, the West Indies, and Central America are also listed, together with citations to the publications in which they were first defined. The principal subsurface units in the United States have been listed, but names of coal beds and ore beds are not included. The arrangement is alphabetical; part 1 contains names beginning with letters A to L; part 2, those from M to Z. The lexicon is sold by the Superintendent of Documents, Government Printing Office, Washington, D.C., at $2.50 for the set.

WATER vs. WATER VAPOR

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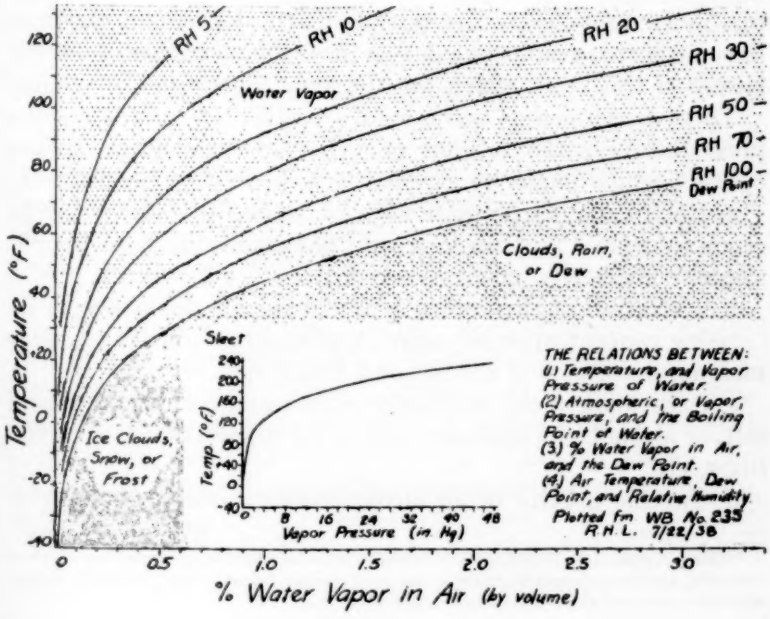
"Why is water precipitated from the air sometimes in liquid form and sometimes in crystalline form?" The author was faced with this problem in attempting to explain to his science pupils the difference between the formations of dew and frost, and between those of rain and snow. He gave the conventional answer that when the dew point is above 32°F. precipitation is liquid; below 32°F., solid. But, his brighter pupils were not satisfied with this answer. They wanted to know why the dew point was sometimes above freezing, sometimes below.

The accompanying diagram is what he evolved to show the conditions for all the forms of precipitation discussed in the usual unit on "Weather," save hail. The presentation is novel in that the form of precipitation is clearly shown as a function of the amount of water vapor in the air. It still shows that when the dew point is above freezing the precipitation is liquid, and below freezing crystalline, but, at the same time, it exposes the dew point itself as a function of the amount of water vapor in the air.



The diagram also throws light on a number of other problems commonly discussed in elementary science. Before discussing the chart and its applications in detail, however, it seems proper to defend such a graph against the possible accusation that the preparation of pupils for the use of it is too difficult. Naturally, there must be some preparation for the use of it. This necessary preparation may be justified on two grounds: first, such a graph shows vividly the nature of a scientific law; and second, there are a great many possible applications of such graphs in teaching elementary science.

"From his experience a scientist may predict that if certain complexes of conditions exist, then certain other complexes of conditions will, or do, exist."[1] This idea is fundamental to science. A prediction made in this way is a scientific law. Graphical representation seems to be the most concise, and most easily comprehended, way of presenting a relation of this type. The very form of Hobson's definition may well be preserved in reading the accompanying graph. For example, "If there is 0.6% water vapor in the air, then the dew point is approximately 32°F." Or, "If the dew point is 70°F., then there is approximately 2.5% water-vapor in the air." Even if no numerical applications are to be made, the graph often pictures the relation more clearly than words can. Authors of elementary science textbooks, and elementary science teachers generally, seem to have neglected graphs as a device for teaching concomitant variations of this kind, which are the very foundation of science.

There are numerous examples of scientific laws which are now presented in some fashion or other in elementary science courses, which might be excellently presented by graphs, viz.:

a. Decrease in air pressure with increasing altitude above the earth's surface. Applications: physiological effects on people, airplane altimeters, etc.

b. Elevation of the boiling point of sugar solutions with increasing concentration of sugar. Applications: control of candy making, avoidance of candy sirup burns, etc.

c. Depression of the freezing point of water by the addition of salt, or alcohol. Applications: salt on icy sidewalks, freezing mixtures, etc.

d. Specific gravity of an alcohol-water mixture vs. the per-

[1] Hobson, quoted in the present writer's "Scientific Attitudes suggested by selected literature from 1880–1936, and their recognition in the literature of General Science," an unpublished Master's dissertation presented at the University of Cincinnati in June, 1938.

cent of alcohol, or vs. the freezing point. Applications: automobile radiator protection charts, etc.

e. Pressure-temperature relations of freezing water. Applications: bursting water pipes, weathering of rocks, ice skating, movement of glaciers, etc.

f. Conversion of temperatures on the Fahrenheit and Centigrade scales.

g. Conversion of English and metric units of measure.

h. Temperature-viscosity relations. Applications: winter and summer motor oils, last sirup from can, etc.

i. Change in duration of daylight period with the season and with latitude.

j. Time vs. the current, or potential. Application: nature of an alternating current.

k. Time vs. amplitude of vibration. Application: nature of a sound wave.

Add to this list the several relations shown on the accompanying diagram, and it becomes quite respectable in length, and in importance of the relations mentioned, Surely the preparation necessary for pupils to understand these and other such relations is well worth giving.

The material below is not only a new and improved treatment of the subject-matter, but also an example of what may be done in science teaching with the graphical presentation of such "cause-and-effect" relationships.

Derivation of the Curves

The curves in the figure were plotted from the data given in *Psychrometric Tables for Obtaining the Vapor Pressure, Relative Humidity, and Temperature of the Dew Point from Readings of the Wet and Dry Bulb Thermometers*, Weather Bureau No. 235. Washington, D.C.: Government Printing Office, 1915. 87 pp. Price 10¢.

(1) The inset Vapor Pressure-Temperature curve was plotted directly from the values given in Table I and Table XI.

(2) Since the boiling point is defined as the temperature at which the vapor pressure of water just exceeds the atmospheric pressure, this same PT curve shows the change in boiling point for ambient pressures other than normal atmospheric pressure, 30 in. of mercury.

(3) The Dew Point curve is an enlargement of the inset PT curve, covering the pressure range of 0 to 1.0 in. of mercury,

and the temperature range of $-40°$F. to $+130°$F. This Dew Point—100% Relative Humidity curve is the same as the PT curve for when the aqueous vapor in the air is exerting its maximum pressure at a given temperature that space is saturated with aqueous vapor. The pressure scale of the Dew Point curve has been converted to a %-Water-Vapor-in-Air scale by applying Dalton's Law of Partial Pressures. Assuming an atmospheric pressure of 30 in. of mercury,

$$\%\ \text{Water Vapor in the Air at temperature } t = \frac{\text{Vapor Pressure at temperature } t}{30}\ 100.$$

(4) The several Relative Humidity curves were plotted by combining data from two tables. The points on the curves were calculated thus:

a. In Table VI there was found a depression of the wet bulb thermometer $(t-t')$ which indicated the selected Relative Humidity (h) at the desired air temperature (t).

b. In Table I there was found the dew point (t'') for the same air temperature (t) and depression of the wet bulb thermometer $(t-t')$.

c. Then air containing enough water vapor to have a dew point (t'') has a Relative Humidity (h) at the temperature (t). Points were thus determined on curves of 5, 10, 20, 30, 50, and 70% Relative Humidities, respectively.

Values of the Diagram

(1) *Temperature, and Vapor Pressure of Water.* In teaching the unit "Air" in his own classes the writer has offered the kinetic theory of gases as the best explanation known for the pressure of the atmosphere and the phenomena directly associated with it. Then, in teaching the succeeding unit "Water," he points out that the vaporization of water, too, is best explained by the kinetic theory. The concept of vapor pressure follows directly from the mental picture of water molecules flying from the liquid water to the space above it, and back again. The kinetic theory requires this vapor pressure to increase with increasing temperature, and to decrease with decreasing temperature. The PT curve inset in the figure shows that this relation required by theory actually exists. Hence, warm water evaporates faster than cold water. Also, it is interesting to note that water in the form of ice below 32°F. has a measurable vapor

pressure. This should make clear why clothes hung outside in winter will dry, even though frozen stiff. The ice sublimes.

(2) *Atmospheric, or Vapor, Pressure, and the Boiling Point of Water.* The boiling point is that temperature at which the vapor pressure of water just exceeds the atmospheric pressure. At a pressure of 30 in. of mercury the boiling point is 212°F. At pressures higher than normal the boiling point is higher than 212°F. —used in pressure cookers to cook food more quickly. At pressures lower than normal the boiling point is lower than 212°F.—used in vacuum evaporators, e.g., to keep from caramelizing sugar. At temperatures higher than normal the pressure is more than 30 in. of mercury—used in steam engines to drive the pistons, etc. At temperatures lower than normal the pressure is less than 30 in. of mercury—used in steam condensers to reduce back pressure on the engine.

(3) *% Water Vapor in the Air, and the Dew Point.* Whenever there is more water vapor in space than is required to saturate it, precipitation takes place. The temperature at which this occurs is called the dew point. The figure shows the conditions for all forms of precipitation studied in the unit on "Weather" except hail. For water vapor contents of 0.6% or more the first water precipitated is liquid—dew, rain, or clouds, including fog. If this liquid water is cooled below freezing, sleet is formed. For water vapor contents less than 0.6% the "dew point" is below freezing, and the precipitated water is crystalline—ice clouds, snow, or frost. Of course, precipitation lowers the amount of water vapor in space. Hence, air containing say 0.7% water vapor on being cooled precipitates liquid water at a temperature just above freezing, but this reduces the moisture content of the air so that continued cooling precipitates crystalline water—snow, frost, etc.

The Weather Bureau reports simply the temperature of the dew point. Obviously, if it is above 32°F. the precipitation will be liquid; below 32°F., crystalline. In elementary science teaching, however, it seems that the connection between the amount of water vapor in the air and the type of precipitation might well be stressed.

(4) *Air Temperature, Dew Point, and Relative Humidity.* The figure shows admirably, too, the changes in relative humidity that take place in various kinds of air conditioning. If the air conditioner is simply a hot-air furnace, with no humidifying

device, supplied with outside air of RH 100 at a temperature of 0°F., the humidity of the conditioned air at a temperature of 73°F. is shown to be only 5%.

This result may be gotten in either of two ways. The easier is this. The chart shows that air saturated at 0°F. contains approximately 0.13% water vapor. Since heating the air does not change its actual humidity, the changes in relative humidity on heating it may be visualized by laying a straight-edge on the chart vertically, and passing through the horizontal scale at the point indicating 0.13% water vapor. Wherever this vertical line intercepts one of the RH curves it shows the temperature at which the relative humidity is that marked on the curve. This vertical line cuts the 5% RH curve at approximately 73°F.

The second method of getting this result from the figure involves a little calculation, but may make the meaning of "relative humidity" stand out in bolder relief. Air saturated at 0°F. contains approximately 0.13% water vapor. When this air is heated to 73°F. it still contains 0.13% water vapor. But the Dew Point curve shows that air at 73°F. might contain as much as 2.72% water vapor. Then the relative humidity is $0.13\%/2.72\% = 4.78\%$, a fairly close approximation to the 5% found in the solution above.

A few examples such as the above will make evident the necessity for humidification of the air passing through our heating systems in the winter time. Incidentally, they will show, too, why warmed air is a better drying agent than cool air—why clothes dry better in a heated basement than in a cold one.

In some air conditioning systems, such as those in theaters and department stores, the humid air of summer is dried by spraying water through it. How water sprays may dry air is difficult for many people to understand. The figure shows, however, that if these sprays cool the air below its dew point moisture will be precipitated. For example, if air at a temperature of 90°F., and a relative humidity of 80%, is cooled sufficiently water is precipitated from it. If it is cooled ultimately to only 60°F., the water vapor content is reduced to approximately 1.8%. Now, if this same air is heated to 80°F. it has a relative humidity of approximately 50%, and furnishes a very comfortable change from the hotter, more humid, outdoor air.

This chart was designed primarily for showing the rational connection between the several forms of water precipitated from the air, and also the changes in relative humidity brought about

by heating and/or cooling air. However, it may be of practical value: first, in determining the percent of water vapor in the air directly from the dew point; and second, in determining the relative humidity from measurements of the air temperature and the dew point. If the chart is to be used with data obtained from hygrometer, or sling psychrometer, readings, some table such as Table I in the *Psychrometric Tables* cited above must be used intermediately.

SCIENCE EXHIBIT OF THE AMERICAN INSTITUTE

The American Institute, in cooperation with the New York City schools, will give a science exhibit this summer at the World's Fair. This exhibit is planned to show a new method of progressive science education which has been developed in New York City in the last ten years, with the direct aid of the American Institute.

Fifty unusual projects, planned and executed by science students between the ages of twelve and eighteen, will be the nucleus of this exhibit. These displays will show in graphic form the result of scientific investigation carried on by students. They will also focus the attention of parents. educators, and laymen on the value of the scientific method as a valid background for creative expression.

The exhibit will include the following fields: Biology, Chemistry, Physics, Physiography, Photography, and Nature Studies. The keynote of the biology exhibit will be the various theories of genetics; of chemistry, the nature of materials; of physics, electronics; of physiography, relief maps.

Some of the exhibits are to be dynamic, some animated, and some static, but all will be accompanied by legends, charts and diagrams, so that the public may easily understand the scientific principles involved. Students will demonstrate some of their own science projects and act as interpreters of their work.

The American Institute feels that there is no force quite so great for the building of honest citizenship as the study of science and its applications in engineering. This science exhibit will stimulate the growth and development of children's science groups throughout the United States. Visitors carrying home the message of this exhibit will want to extend this work to their own communities.

BIRD-BANDING DURING 1938

A total of 1,749 birds, representing 57 species, were banded during 1938 at the eight bird-banding stations maintained in the areas comprised by the 26 Southwestern Monuments of the National Park Service.

In consonance with the conservation policy of the United States Department of the Interior, ornithological studies are carried on continuously in the areas it administers. Many valuable contributions to scientific management of our natural resources are by-products of these studies. Relation of bird population and insect infestation of trees is but one example of such useful data.

AVAILABLE MOTION PICTURES IN RELATION TO CURRICULUM NEEDS IN BIOLOGY

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The most comprehensive and thorough-going evaluation yet made of the motion picture material available for education was that done under the auspices of the Motion Picture Producers and Distributors of America during the summer of 1937. The writer was fortunate in being a member of the panel that studied the films available for biological science. Originally the project contemplated including only the available theatrical short subjects. Many educators had looked with longing eyes on the valuable picture material locked in the vaults of the motion picture industry. Now these doors were unlocked.

The survey had not proceeded far before it was felt that non-theatrical pictures should be seen and the Executive Committee of the M.P.P.D.A. magnanimously agreed to have them included in the survey. This report is based, therefore, on all available short subjects from R.K.O., Warner Bros., Twentieth Century-Fox, Paramount, Metro-Goldwyn-Mayer, and others, going back about ten years, and from educational and industrial film producers, including Eastman Teaching Films, Erpi, Bray, Instructional Films, Gaumont-British, British Instructional Films, and General Electric. This represents, therefore, a thorough sampling, if not an exhaustive list. For the first time most of the available material was reviewed and evaluated by the common standards of a single committee. To that extent it is, we believe, a contribution to educational research.

What is the present source of available pictures for science education? Despite keen anticipation, when we learned that the vaults were to be opened, the contribution from the theatrical field was meager, though frequently technically superb. The very recent Paramount Popular Science Series is indicative of such excellence.

In our survey, no more than 30 per cent of the pictures—good, bad, and indifferent, were of theatrical origin. However, the vaults undoubtedly contain thousands of feet of unedited material that may some day be made available. Moreover, many feature films contain sequences that were not included in our study, but which would make desirable educational film material. The locust plague as pictured in The Good Earth

is a case in point. Feature pictures, such as Louis Pasteur, should also be included. There are available, too, many industrial films or series of films. Those of the General Electric Co. are better than typical. This source, too, is relatively meager. Besides, the organization and emphasis in such pictures are both frequently of questionable value for classroom films.

It appears, therefore, that educational films are made chiefly by educational producers. This has an advantage in the fact that the product is presumably planned and designed for school use. How well this is done is sometimes debatable. A disadvantage lies in the inadequate technical equipment and financial resources of many of these concerns, resulting in mediocre products. Many of the Eastman, Erpi, Gaumont-British, and British Instructional films do show that technical perfection may be combined with educational direction.

How well do present pictures meet the curriculum needs in biology? Let us consider important concepts, topics, and units of study and analyze the films available for developing them. The study of classification contributes not only an important concept, but teaches also several essential biological techniques. Our pupils are necessarily lacking in background experiences. Pictures can supply them conveniently, attractively, vicariously. Checking over our list of titles, we find the following:

The Amoeba; Tiny Water Animals; Microscopic Animal Life; Hydra; Obelia; Living Jewels (lower invertebrates); Annelid Worms; Neptune's Mysteries (Molluscs); Hermits of Crabland; Spiders; a large number of films about Insects; Lung Fish; Shark Fishing (and others on fishing); The Frog (four different films); Reptiles; Wild Wings (Birds); Beach Masters (Seals); Oregon Camera Hunt (small Mammals).

These films are, almost without exception, technically excellent. In a course in zoology they would be very appropriate. In general biology, or the biological aspects of general science, they represent too thorough and detailed a development. We could not possibly show such a collection, nor could the showing of them be justified in terms of all the educational needs of the pupils in these courses. What an opportunity for an editor and a pair of scissors! A picture—or several—could be cut from the above titles that would be an excellent survey of the animal kingdom. Unfortunately, all the films are not owned by a single producer or distributor.

For plant classification, little material is available. The spermatophytes have been pictured in various aspects of structure,

nutrition and economic importance. Two films on saprophytic plants and two on plant parasites (both on the dodder) complete the list. Perhaps the nature of the material does not warrant the use of motion pictures. Still pictures may, for most purposes, be adequate here.

Consider next the study of Ecology, which contributes an understanding of plant and animal relationships. There are many beautiful and interesting pictures available. We may mention only representative ones: Beneath Our Feet (insects of the field); Beneath the Sea (marine life); Hermits of Crabland; Swampland; Nursery Island; Butterflies and Nettles; White Flies and Tomatoes; etc. There are many theatrical shorts in this category, and many are exceptional in content and presentation of characteristic animal associations. Plant material is again lacking.

The importance of a knowledge of reproduction in understanding genetics, heredity, breeding and sex hygiene may be reflected in the number of films listed under this subject. There are approximately fifty that are designated by titles, and others include sequences on reproduction incidentally. That these films have been produced almost altogether by educational producers is desirable. Excellent pictures are available to illustrate the process in all representative forms. Since this survey was completed, several pictures have been announced on mammalian reproduction, completing the list. There has been in use for many years a picture which is a survey of reproduction in the plant and animal kingdoms. Technically rather mediocre, it has nevertheless had extensive use because there has been no comparable film. What an impressive film could be made from sequences of the pictures included in this survey!

A review of the large number of films (approximately 110) devoted to the study of specific animal forms or groups, reveals that a course in zoology may profit more from available material than one in general biology, where the material must be integrated in terms of broader concepts. Again an editorial job is indicated.

Let us examine some of these concepts. *Adaptation* reveals titles such as Nature's Armor; Plant Traps; How Nature Protects; Self Defense by Plants; Stable Manners (feeding habits). This list is limited, and the pictures are generally mediocre. It must be recognized, however, that there are many other films which contain valuable material on this subject, and in the

hands of a competent teacher they may well be used to present objective evidence of adaptations. Most of the pictures listed under "Classifications" have much to contribute. However, pictures that cut across animal or plant groups and illustrate how many different forms meet the same problem would be preferable.

The Struggle for Existence is shown well in parts of many pictures. An interesting series of pictures, entitled, "Struggle to Live Series" develops this theme. The idea may be conveyed by the intensive study of the struggle in one form, but it seems probable that a deeper and fuller understanding could be developed by a broader treatment. Again, the picture material is available, and an editorial job is desirable.

The intimate relationship of plants and animals characteristic of parasitism is treated, though incidentally, in several films: The Housefly; Life History of Yellow Fever Mosquito; Plant Parasitism (appears only twice); Dodder and Nature's Gangsters (also dodder); Symbiosis (shown in parts of several films); Battle of Centuries (termites and protozoa); Wood Ants (ants and aphids).

The need for conservation, as well as methods involved, may well be shown by means of motion pictures. We need not here emphasize the importance of the topic in this day. Yet this topic appears in only a few films, and then only incidentally. There is no Plow That Broke the Plains, or The River among the films we reviewed for biology.

The economic aspect of biology is treated in about thirty films on plant and animal subjects. Many of these are of industrial origin and, therefore, a large part of the content of each is concerned with the operation of machinery. Moreover, most of pictures are old and out-dated. Titles characteristic of this group are: The Sugar Trail; A Woolen Yarn; From Flax to Linen; Corn; Mackerel; Cod; Wheat; etc. There is a great need for films on the economic aspect of biology, planned around broad, unifying concepts, and emphasizing the impact of these economic aspects on people. Films on agriculture and forestry, which are included in this category exemplify the inadequacy of available film materials for this important aspect of biology.

For the two great unifying concepts of biological science, there is little to be had. There are five titles on the cell—two on microscopic animal life, one on the amoeba, one on the cell, and one on bacteria. They give only a limited idea of the importance

of the cell and its activities. On the subject of evolution we have only incidental material. One film, "Digging into the Past" shows how fossils are excavated. There is a picture, not included in this survey, dealing with evolution, but it merely emphasizes by its inadequacy, the need of pictures in this area. There is much valuable material in such films as: Battle of the Centuries; Lungfish; Undersea Life, etc., that may be culled to make a film illustrating the principles of overproduction of offspring, competition, adaptation. Generally, the material in this category is entirely inadequate, particularly in the light of its relative importance.

Pictures on plant and animal breeding and genetics are almost completely lacking. One film, Luther Burbank, is available. Some material has been produced in Soviet Russia in this area, but is apparently not satisfactory for our use.

Human biology is given extensive treatment in films from educational sources. All common physiological functions and their hygienic implications are included. The organization of these pictures, with respect to aim, content and psychological development is often open to question. In general, such films are pitched at a higher level than the high school population warrants, are too inclusive, lacking in motivation and thought stimulation.

On the question of disease control, there are few available films. The following titles appear: Life History of Yellow Fever Mosquito; Housefly; Bacteria; Diphtheria; Tuberculosis. An essential characteristic of such pictures—strong motivation to influence behavior—is lacking in them.

The pictures included in this survey, theatrical, educational and industrial, are generally descriptive. This is well done, particularly in the theatrical films and in many of the educational ones. Critical thinking, motivation for desirable attitudes and behavior are seldom included. In the hands of skilled teachers these films may lead to desirable outcomes, but it is preferable to have the film tell its own story to insure the kind of learning for which it was designed. Skillful editing of much of this material will be a great boon to teachers of biology.

To summarize, the motion picture material available in biological science is abundant, frequently of technical excellence, but not adequately adapted to curriculum needs. This survey has been of inestimable value in revealing what there is available from all sources, in evaluating this material, and in sug-

gesting possibilities for further improvement. Progress may come from improved techniques of using available material, from revising these films, or by producing new ones. Economy favors the first two.

TITLES OF MOTION PICTURES INCLUDED IN THE SURVEY OF FILMS FOR BIOLOGY TEACHING

NOTE: This list includes all pictures viewed, regardless of rating. The title does not always reveal the contents in full. A cross-indexed catalog of all the films included in the survey has been prepared, including the recommendations of the committee.

CLASSIFICATION: ANIMAL AND PLANT

Cannibals of the Deep; Beneath the Sea; Neptune's Mysteries; Living Jewels; Hermits of Crabland; Birds of the Sea; Pirates of the Deep; The Sea; Oregon Camera Hunt; Spiders; Animals of the Zoo; Tiny Water Animals; Obelia; Earthworm; Annelid Worms; The Amoeba; Animal Life; Beach and Sea Animals; Plant Life; Camera Hunting; Adventures of Peter; Frogs, Toads and Salamanders; Microscopic Animal Life; Reptiles; Oysters; Rocky Mountain Mammals; Sea Urchin; Hydra.

BIRDS

Wild Wings; Birds of the Sea; Woodland Pals; Our Bird Citizens; Our Sea-Going Birds; Development of Bird Embryo; Game Birds; Bird Homes; Birds of Prey; Birds of the Sea Coast; Some Friendly Birds; Wading Birds; Stuffed Grouse; Nesting Time; Perching Birds and Birds of Prey; Pelicans, Cormorants, Ducks and Swans; Wingless Birds; Miscellaneous Birds; Birds; The Green Plover; A Family of Great Tits; Black Headed Gulls; The Sparrow Hawk.

FISH

Cannibals of the Deep; Freaks of the Deep; Gangsters of the Deep; Adventures of a News Reel Camerman; Trail of the Sword Fish; When Fish Fight; Under Sea Life; Fishing Highlights; Pacific Coast Salmon; Mackerel; Cod; The Lungfish.

FROGS

Leaping through Life; The Frog (Erpi); The Frog (Gaumont-British); He Would A-Wooing Go; Amphibians; Development of Salamander; Salamanders, Newts and Allies.

REPTILES

Reptiles; Viperine Reptiles; Boas and Pythons; Poisonous Reptiles; Reptiles; Old World Lizards; Turtles and Tortoises.

INSECTS AND ARACHNIDS

Beneath our Feet; Battle of the Centuries; City of Wax; Deadly Females; Underground Farmers; Butterflies; Aphids; Spiders; Housefly; Butterflies and Nettles; Moths; Beetles; Life History of Yellow Fever Mosquito; Some Water Insects; Termites; Spiders; Housefly; Silk; Blow Fly; White Flies and Tomatoes; Wood Ants; Looped Caterpillars.

MAMMALS

Beach Masters; Forest Gangsters; Adventures in Africa Series; Wild Life in the Veldt; Giants of the Jungle; Giants of the North; Taming of the Wildcat; Oregon Camera Hunt; Animals of the Zoo; Wake Up and Feed; Beavers; Rocky Mountain Mammals; Some Large Mammals; Billy Blue Gum; Making Friends in the Desert; Sheep; Carnivorous Bovines; Bears; Hoofed Animals; Anthropoid Apes; New World Monkeys; Old World Monkeys; Canines and Small Carnivores; Smaller Carnivores; Smaller Rodents; Larger Rodents; Prairie Dog and Beaver; Insectivores; Marsipals; Kangaroos; Nature's Nurseries; Leaping through Life (frog); Our Sea Going Birds.

ADAPTATIONS

Seed Dispersal; Wild Wings; Underground Farmers (ants); Nature's Armour; Housing Problems; Flowers at Work; Plant Traps; Stable Manners (feeding); Annelid Worms; Wake Up and Feed; How Nature Protects; The Skin; The Lungfish; Marine Sand Animals.

MARINE LIFE

Cannibals of the Deep; Freaks of the Deep; Gangsters of the Deep; Neptune's Mysteries; Living Jewels; Beach Masters; Hermits of Crabland; Trail of the Swordfish; The Sea; Beach and Sea Animals; When Fish Fight; Some Seashore Animals; Undersea Life; Let Us Go Crabbing; Marine Sand Animals; Marine Life; Depths of the Sea; Shore Life at Low Tide.

PLANT LIFE

Seed Dispersal; Nature's Gangsters; Fungus Plants; Plant Growth; Flowers at Work; Plant Traps; Seed Production; Leaves; Roots of Plants; Dodder; Conquest of the Forest; A Wollen Yarn; Sugar Trail; World of Paper; Sugar; Land of Cotton; Plant Life; From Flower to Fruit; Green Plant; Wild Flowers; Molds and Yeast; From Flax to Linen; Coffee; The Cabbage; Thistledown; Self-Defense by Plants; Lupines; Queer Diets; Roots.

FORESTRY AND AGRICULTURE

Conquest of the Forest; Our Daily Bread; World of Paper; Spring in the Fields; Sugar; Land of Cotton; The Lambs; Reforestation; Planting and Care of Trees; From Flax to Linen; Corn; Cotton Growing; Wheat; Range Sheep; Coffee.

CONSERVATION

Wild Wings; Beach Masters; Forest Gangsters; Wild Life of the Veldt; Birds of the Sea; Cougar's Mistake; Taming of the Wild Cat; Nursery Island.

ECOLOGY

Wild Wings; Beneath the Sea; Battle of the Centuries; Beneath Our Feet; Forest Gangsters; Hermits of Crabland; Swampland; Underground Farmers; Adventures in Africa Series; Wild Life of the Veldt; Giants of the North (bears); Oregon Camera Hunt; Adventures of Peter; Beavers; Game Birds; Bird Homes; Birds of the Sea Coast; Wading Birds; Rocky Mt. Mammals; Some Large Mammals; Some Sea Shore Animals; Some Water Insects; Marine Life; Depths of the Sea; The Green Plover; Nursery Island; Life of the Tawny Owl; White Flies and Tomatoes; Interdependence of Pond Life.

ECONOMIC BIOLOGY

Giants of the Jungle (elephants); Aphids; Beetles; Sugar Trail; A Woolen Yarn; Conquest of the Forest; Our Daily Bread; World of Paper; Sugar; Land of Cotton; The Lambs; Life History of the Yellow Fever Mosquito; Planting and Care of Trees; Oysters; Termites; Fishing High Lights; Pacific Coast Salmon; From Flax to Linen; Corn; Cotton Growing; Shark Fishing; Mackerel; Cod; Wheat; Silk; Coffee; Seal Hunting in the Arctic; The Cabbage; White Flies and Termites.

MISCELLANEOUS PRINCIPLES

Battle of the Centuries (Symbiosis); Deadly Females (sexual selection); Nature's Gangsters; (parasitism); Reactions in Plants and Animals (tropisms); How Nature Protects; Wood Ants (Symbiosis); Looped Caterpillars (protective resemblance).

EVOLUTION

Struggle for Existence; Beneath Our Feet; Battle of the Centuries; Wild Wings; Animal Cunning; Deadly Females; Underground Farmers; The Sea; Butterflies; Luther Burbank; The Cabbage.

NATURE STUDY: OUTDOOR BIOLOGY

Beneath Our Feet; Bosom Friends; Chums; Chummy with Chipmunks; Housing Problems; Woodland Pals; Camera Hunt; Oregon Camera Hunt; Adventures of Peter; Mixed Bathing; A Family of Great Tits; Roger the Raven, and many of the titles listed above.

HUMANE EDUCATION

The Seeing Eye; Vagabonds (dog hospital).

CELLS

The Living Cell; Bacteria; The Amoeba; Tiny Water Animals; Microscopic Animal Life.

DISEASE PREVENTION

Life History of the Yellow Fever Mosquito; Bacteria; Diphtheria; Housefly; The White Wings of our Bodies; Tuberculosis.

PHYSIOLOGY AND HYGIENE

Heart and Circulation; The Seeing Eye; Nervous System; Mechanics of Breathing; Reactions in Plants and Animals; The Blood; Body Framework; Breathing; Circulation; Circulatory Control; Digestion; Feet; Food and Growth; Muscles; The Skin; How Teeth Grow; Blood; Breathing; Clean Face and Hands; Keeping the Hair Clean.

REPRODUCTION

City of Wax (insects); Wild Wings; Seed Dispersal; Beach Masters; Hermits of Crabland; Nature's Nurseries; Leaping Through Life (Frog); Our Sea Going Birds; Fungous Plants; Plant Growth; Flowers at Work; Butterflies; Aphids; Spiders; The Housefly; The Frog; Obelia; The Earthworm; Seed Production; Butterflies and Nettles; The Frog; Moths; Beetles; Development of the Bird Embryo; Bird Homes; Frogs, Toads and Salamanders; From Flower to Fruit; Oysters; Ruffed Grouse; Termites; Spiders; Housefly; Pacific Coast Salmon; Development of the Salamander; Ovulation; The Sea Urchin; Birds; Blow Fly; He Would A-Wooing Go (Frog); Black Headed Gull; The Sparrow Hawk; The Life Story of the Tawny Owl; Thistledown; Wood Ants; Looped Caterpillars; Lupines; Roger the Raven; Hydra.

MAKING HIGH-SCHOOL CHEMISTRY PRACTICAL

WILLIAM C. CURTIS
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Today the complexion of the high-school curriculum is rapidly changing. The courses of study for many of the subjects offered on this level are now in the process of drastic revision. The general purpose of these changes is to increase the practicality and flexibility of secondary education. Most of the courses in traditional chemistry and physics are apparently not in harmony with the modern trends in secondary education. The popularity of these courses is rapidly decreasing at the expense of a rising interest in biology.

The purpose of this article is to stimulate an interest in a consideration of the curriculum reforms which may be introduced to encourage students to study high-school chemistry. Any steps taken in this direction should not be in competition with biology or physics. We are living in an age in which the applications of all three sciences play an ever-increasing part in our daily lives. All three subjects, therefore, have their place in the curriculum of a secondary school.

The conventional high-school chemistry courses should be revised so as to provide the students with a practical knowledge of chemistry which will enable them to better appreciate and adapt themselves to their environment. To this end, the courses of study should be reorganized on a practical basis and more effective methods devised for utilizing the laboratory. Moreover a more widespread use should be made of project teaching and planned trips.

Progressive courses of study should include that subject material which is considered essential to an understanding of chemistry, together with adequate provision for supplementary material which will be of value to students in later life. The supplementary material should be dictated by the local conditions. In large agricultural centers this material should be based primarily upon the applications of chemistry to agriculture.[1] Such subject material, however, would be of minor importance in a community such as Brooklyn, New York. Here the local conditions would call for emphasis on the applications of chemistry to the industries characteristic of the community. In Washing-

ton, D. C., which is neither an agricultural nor an industrial center, the local essentials would probably be based upon the applications of chemistry to everyday vocations.

A brief outline of the topics which would form an appropriate basis for most chemistry courses of study is given below. This outline is based on the actual needs of pupils entering the adolescent period.

Outline of Subject Matter

Definition and Scope of Chemistry
Fundamental Concepts and Nature of Matter
Changes of State and Kinetic Theory
Fundamental Laws of Chemistry
Characteristics of Chemical Changes
Valence and Chemical Formulas
Representation of Chemical Changes by Equations
Mixtures vs. Compounds
Preparation, Properties, and Uses of Common Elements and Compounds
Chemistry of Solutions
Chemistry of Electrolytes and Ionic Theory
Chemistry of the Colloidal State
General Properties of Gases
Oxidation-Reduction Reactions
Chemistry of Hydrocarbons and Their Derivatives
Chemistry of Foods and Their Adulteration
Chemistry of Everyday Life
- Common Metals and Alloys and Their Use
- Paints, Pigments, and Varnishes
- Applications of Electrochemistry
- Applications of Textile Chemistry
- Preparation of
  - Common drugs and cosmetics
  - Cleaning preparations
  - Disinfectants, antiseptics, and insecticides
  - Inks and ink removers
- Chemistry of
  - Community sanitation
  - Gasoline engines
  - Glass and porcelain
  - Flames and fuels
  - Home gardens and aquariums
  - Photography
  - Plastics
  - Ventilation and refrigeration

Recent Developments in Chemistry
Vocational Opportunities in Chemistry

The problem of reorganizing the methods of laboratory instruction so as to attain the desired outcomes is one of the most important considerations in chemical education. Ralph E. Horton has made an extensive investigation of the traditional laboratory methods employed in the teaching of high-school chemistry.[2] The results of his investigation furnish a convenient

basis for reorganizing the laboratory work in terms of measurable outcomes.

A combination of the demonstration and problem solving methods seems to afford the most practicable procedure for conducting the laboratory work. The demonstration method should be used to present important phenomena and experimentation, essential to the acquisition of the minimum essentials of the course. One phase of the individual laboratory work should consist of experiments designed to enable the pupils to acquire the desired manipulative skills and abilities. The other should involve a form of individual research in which the students attempt the solution of problems "by supervised, but undirected experimentation." The outcomes of such procedure can be determined in terms of the pupils' achievement. Then too, this mode of laboratory instruction can be adjusted to meet the needs, interests, and abilities of the pupils, and readily lends itself to project teaching.

The practicality of high-school chemistry can be further increased by a more extensive use of project teaching. Projects should represent a type of creative research on the part of the students. They should arise from some phase of class work, and represent a series of actual learning activities. The pupil should at every stage in the completion of a project "be able to say that having used these materials in this way, I learned—thus and so." The teacher should make sure that each project is practical, feasible, and measures the capacity of the student undertaking it. When the students complete their projects they should explain them to the class as a whole, justifying the conclusions they have reached.

As an illustration of the proper method of employing project teaching in chemistry, we may select a project on bleaching powder. The idea for this project could be developed out of a class discussion of a unit on oxidation-reduction reactions. The students could be asked to name several of the bleaching agents they have in the home. Undoubtedly the students would mention certain industrial products containing bleaching powder. This would give rise to the question as to what substance forms the active ingredient of products of this type. A problem situation could then be created and used as a basis for assigning the project, consisting of a series of related learning exercises. The project could be organized along the following lines:

1. *Preparation of Bleaching Powder.*—Pass chlorine gas through a tube of moist lime. Collect the escaping chlorine in a solution of sodium hydroxide, containing a crumpled ball of stiff paper.

Why do you think the lime has to be moist?
Write an equation for the reaction between the lime and chlorine.
Write an equation for the reaction of chlorine on a solution of sodium hydroxide.
Why was the paper added to the sodium hydroxide solution?

2. *Properties of Bleaching Powder.*—The student will be required to answer questions similar to the above in connection with the following experiments.

(a) Exposure of bleaching power to air
(b) Determination of available chlorine—action of sulphuric acid on bleaching powder
(c) Interaction of cobalt nitrate and bleaching powder solutions
(d) Bleaching action of solutions of bleaching powder
(e) Effect on various textiles
(f) Formation and detection of oxycellulose
(g) Interaction of sodium carbonate and bleaching powder solutions

3. *Conclusions.*—

What per cent of available chlorine should commercial bleaching powder contain?
How should bleaching powder be packed and stored?
Why are solutions of bleaching powder kept in dark containers? Why are they corked with rubber stoppers?
For what textiles is the use of bleaching powder unsuitable? For what textiles is its use suitable?
How should it be used in bleaching cotton? Linen?
What is meant by "chemicking"? By "souring"?
How can the formation of oxycellulose be prevented?
Why is much damage done in domestic and commercial laundries through the ignorant use of bleaching powder?
Name several reagents which may be effectively employed in removing bleaching powder from goods.
What substance is now displacing much of the bleaching powder of commerce?
Name several methods for preparing sodium hypochlorite.
Describe the preparation and uses of Javel water, Zonite, and Labarraque's solution.

The accumulation of suitable material is a very important phase of project work. The students should be required to bring in current articles pertaining to chemistry. Carefully indexed scrap files or books should be prepared from this material. Written reports, charts, descriptions of apparatus and experiments, etc., which may be useful in project work should also be systematically filed for future reference. The chemistry teacher should contact various chemical firms and request specimens of their raw materials and finished products. In so doing, it is best to correspond on school stationery, clearly stating what materi-

al is desired and the purpose for which it is intended. Museums composed of these specimens and mounted photographs of various chemical products and processes can be kept constantly on exhibition and new material added from time to time.[3]

Arrangements should be made to take the chemistry classes on inspection trips to the chemical plants in the vicinity of the school. These trips should be carefully planned and form an important part of the class activities. The pupils should be adequately prepared for the trips by the necessary classroom instruction. They should also be required to fill out questionnaires calling for certain specific information pertaining to each plant visited. Written quizzes based on these questionnaires should follow each trip.

Attempts have been made to provide high-school students with a practical knowledge of chemistry by the organization of second year courses.[4] Such courses afford an opportunity to place greater stress on the foundation principles in the first year course, thereby providing the students with a good background for the acquisition of a knowledge of the utilitarian value of chemistry. Unfortunately, however, relatively few high schools have a place for the second year of chemistry in their curriculum. In most high-schools both the foundation principles and applications must be included in the conventional course.

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METHODS IN ARITHMETIC AND ALGEBRA

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I have been in high school and college work all of my days until I came to St. Louis. It is a great pleasure to develop the right foundation for high school and college work. I like to place all mathematics in a reasoning and attractive form. If it has this basis, there will be little failure in high school and college. City high school failures in St. Louis are about 15%. Those from my school are about 1%.

Mathematics is a great problem in grade schools and high schools unless presented to pupils on the basis of reasoning.

For this reason we have developed arithmetic so that it is understood and is interesting. The world is too big to memorize.

Our ten-table is a great help in our understanding. Here is a sample: My second grade pupils know that they do not *borrow*. That is just a name for what they do.

In second grade they have addition and subtraction. They understand what borrowing means. There is no real borrowing.

They know: $16=10+6$, $21=20+1$, etc.

They know addition facts and then have the reason for that unfair borrowing.

Sample:

$$\begin{array}{rl} 34 & \text{is } 20+14 \\ -8 & \quad -\ 8 \\ \hline & \quad 20+\ 6 \text{ or } 26. \end{array}$$

They never have to borrow from the minuend and pay it back to the subtrahend, as some people do.

They understand that this thing *called* borrowing is simply a change of form.

We will open our talk with the third grade:

Through first and second grades they have learned the ten-system. In grade III they learn the usual ways of adding and also have a touch of the business ways:

$$\begin{array}{rl} 25+13+16= & 54 \quad (20,\ 30,\ 40,\ 46,\ 49,\ 54) \\ 18+12+21= & 51 \quad \text{The ten system is known and used.} \\ 15+19+24= & 58 \\ \hline 58+44+61= & 163. \end{array}$$

These forms are in use in business reports with 6-place numbers.

Pupils also understand their tables. Not just memorize.

Here is what they get:

4×2 2×4 $2)\underline{8}$ $4)\underline{8}$ $\frac{1}{2}$ of 8 $\frac{1}{4}$ of 8, etc. for all tables.

This gives them a fine understanding, makes the work easy, and builds up the future tables.

When they have finished the 6-table they have only three new facts to learn in the rest of the tables.

The third grade also does simple long division work.

They can also play with such numbers as

$$142857\times2, \text{ or } 3, \text{ or } 4, \text{ etc.}$$

The figures just shift: $142857\times3=428571$.

We have some numbers of this type which have thirty figures to shift. They think that work is fun.

After learning the usual multiplication tables, they study the ten-system and know large, easy tables.

Here is a sample of the work: $5\times4=20$, $5\times40=200$.

Then 5 times the 40's is 200 plus the 5-table.

$5\times40=200$	They have all tables up to 9×80's.
$5\times41=205$	$9\times80=720$
$5\times42=210$	$9\times81=729$
$5\times43=215$	$9\times82=738$
$5\times44=220$	$9\times83=747$
etc.	etc.

Then the fourth grade finds long division easy. Since they know all tables, they know at once how many times such a divisor as 876 will go in.

In the fourth grade, the average of the class in dividing 7-place numbers by 3-place numbers is five examples in seven minutes. The quick pupils do 5 examples in 5 minutes.

They have had feeling for fractions since the third grade, so that the work in grade V is easy.

Here is some fourth grade flash card work:

8×17	9×13	Add	7	8	15	23	17
			6	3	27	25	36
			9	5			

Reduce: $\frac{24}{36}$, $\frac{28}{35}$.

They have dozens of this type and have no time to figure out. It is truly flash work.

Grades V and VI.

They have such multiplication tables as

$\frac{1}{2}\times 8$	$\frac{1}{3}\times 15$	$\frac{1}{4}\times 12$ etc.
$\frac{2}{2}\times 8$	$\frac{2}{3}\times 15$	$-\times 12$
$\frac{3}{2}\times 8$	$\frac{3}{3}\times 15$	$\frac{3}{4}\times 12$
etc.	etc.	etc.

They are then ready to multiply any fraction by a common denominator.

If they must reduce $\frac{5}{12}$ and $\frac{7}{9}$ to a common denominator, they just say,

$36\times\frac{1}{12}$ is 3; then $\frac{5}{12}$ is $\frac{15}{36}$.
$36\times\frac{1}{9}$ is 4; then $\frac{7}{9}$ is $\frac{28}{36}$.

This method is a great help for addition, subtraction and division.

Here is a sample: $\frac{5}{6}\div\frac{7}{8}$. Multiply by 24.

$24\times\frac{1}{6}$ is 4, so $\frac{5}{6}$ is 20
$24\times\frac{1}{8}$ is 3, so $\frac{7}{8}$ is 21.

Only one move is needed. The pupil just does all of this mentally and says

$$\frac{5}{6}\div\frac{7}{8}=\frac{20}{21}.$$

They are now ready to divide mixed numbers by looking at them and writing the answers.

Here is a sample:

(We never use improper fractions, and the business world to-day is using mixed numbers.)

$2\frac{1}{2}\div 3\frac{2}{3}$. Multiply by 6.
$6\times\frac{1}{2}=3$. $6\times 2=12$. Then $3+12=15$
$6\times\frac{1}{3}=2$. Then $\frac{2}{3}$ is 4. 6×3 is 18. Then $4+18=22$.

The pupil just looks at it and says,

$$2\tfrac{1}{2}\div 3\tfrac{2}{3}=\frac{15}{22}.$$

If it is $12\frac{1}{2}\div 3\frac{2}{3}$, he says it is 60 more for the dividend.

Also:

$$\frac{112\frac{1}{2}}{13\frac{2}{3}}=\frac{15+660}{22+60}=\frac{675}{82}.$$

They were allowed to write nothing but the answer in this work.

Here are some samples of mental tests for grades V and VI.

1. $312\frac{1}{2} \div 13\frac{2}{3} =$ 2. $412\frac{1}{2} \div 413\frac{2}{3} =$
3. $25\frac{3}{8} \div 32\frac{3}{4} =$ 4 $125\frac{3}{8} \div 232\frac{3}{4} =$
5. $1718\frac{3}{8} \div 812\frac{1}{2} =$

This makes the work easy for grades V and VI, and also gets them ready for algebra forms which they enjoy:

Multiply by L.C.D.:

$$\frac{2\frac{1}{2}+\frac{3}{8}+\frac{1}{4}}{3\frac{2}{5}+\frac{3}{4}-1} = \frac{50+12+5}{68+15-20} = \frac{67}{63}.$$

In these complex fractions, they make two moves.

We will now present another new method which the business world is taking on to-day.

Multiply:

$2\frac{3}{4}$
$3\frac{4}{5}$

$\frac{12}{20}$ (Never reduce the first fraction because the product always contains the L.C.D.)
$1\frac{3}{5}$
$2\frac{1}{4}$
6

$10\frac{9}{20}$

Here is a sample of the wholesale business work to-day.

A house sells:

$207\frac{3}{4}$ yards at $18\frac{1}{2}$¢
$18\frac{1}{2}$

$\frac{3}{8}$
$103\frac{1}{2}$
$13\frac{1}{2}$
1656
207

3843 Bill: $38.43.

Grade VII

We make the *pure decimal fractions* interesting, get students ready for science work and also get them acquainted with exponents.

$2^1 = 2$ $5^1 = 5$
$2^2 = 4$ $5^2 = 25$
$2^3 = 8$ $5^3 = 125$

$2^4 = 16$ $\qquad$ $5^4 = 625$
$2^5 = 32$ $\qquad$ $5^5 = 3125$
$2^6 = 64$ $\qquad$ $5^6 = 15625.$

We do not say decimals. We say *decimal fractions.*

(A common fraction with a power of 10 for the denominator.)

$$2^1 \cdot 5^1 = 10$$
$$2^2 \cdot 5^2 = 100$$
$$2^3 \cdot 5^3 = 1000$$
$$2^4 \cdot 5^4 = 10000$$
$$2^5 \cdot 5^5 = 100000$$
etc.

Then

$$\frac{3}{8} = \frac{3}{2^3} = \frac{3 \cdot 5^3}{2^3 \cdot 5^3} = .375.$$

When the exponent is 3, it is a 3-place decimal fraction.

Decimal fractions to common fractions:

$$.12 = \frac{12}{100} = \frac{2^2 \cdot 3}{2^2 \cdot 5^2} = \frac{3}{25} \quad \textit{No cancelling.}$$

$$.625 = \frac{5^4}{2^3 \cdot 5^3} = \frac{5}{2^3} = \frac{5}{8}.$$

Factors and exponents are help for arithmetic and give a feeling for algebra forms.

Easy Proportion Understanding

Are these sentences correct?

2 is to 3 as 6 is to 9
2 is to 3 as 8 is to 12
2 is to 3 as 10 is to 15
2 is to 3 as 12 is to 18.

Now express them in fraction form:

$\frac{2}{3} = \frac{8}{12}$. $\frac{2}{3}$ rds. $= \frac{8}{12}$ ths., is the same as the sentence above.

The first form is the *proportion form* but what it means is the equality of two fractions.

Now write this form: $2 \div 3 = 8 \div 12$.

In the proportion form the lines in $\div$ are erased and the central part of the equal sign is erased. The division form then becomes

2:3::8:12.

Then it reads like the sentences above.

In proportion, the product of the extremes equals the product of the means.

The earnest way to show proportion is in the fraction form:

$\frac{2}{3}=\frac{8}{12}$ 2 is to 3 as 8 is to 12.

To prove this, just cross multiply numerators and denominators.

This is useful in proving the equality of fractions when either changing to lower terms or to higher terms.

Unit fractions are helpful in the middle grades.

Here is a sample: Prove the proportion is correct.

$$\frac{8953}{71624}=\frac{9321}{74568} \qquad \begin{aligned} 74568\times 8953 &= 667607304 \\ 71624\times 9321 &= 667607304 \end{aligned}$$

Here is a sample of a set of forty-five fractions that can be placed in 600 different proportions and be proved correct. Each fraction has all nine figures. This is good practice for the middle grades, and gives a good understanding and *feeling* for proportion.

$$\frac{4691}{37528}, \frac{9182}{73456}, \frac{3187}{25496}, \frac{9523}{76184}, \frac{7312}{58496}, \frac{5916}{47328}, \frac{6479}{51832}, \frac{5371}{42968}.$$

Here are some of the uses of our nine figures:

Multiply and reduce to the lowest terms:

$$\frac{6927}{13854}\times\frac{2769}{13845}=\frac{1918063}{19180630}$$

$$\frac{7329}{14658}\times\frac{9267}{18534}\times 4=\frac{271671372}{271671372}.$$

Interest Method easy for the business world:

Interest on \$2400 for $16\frac{2}{3}$ years at 6% will equal the principal.

$6\%\times 16\frac{2}{3}=100\%$. $16\frac{2}{3}$ years $=200$ mo.

This is the wonderful key.

Use no multiplier larger than 2.

Table: Interest at 6% = Principal in 200 mo. (6000 days)
= .1 Prin. in 20 mo. (600 days)
= .01 Prin. in 2 mo. (60 days)
= .001 Prin. in 6 da. (6 days)

Sample: \$3600 at 6% for 1 yr. 10 mo. 3 da.
1 yr. 10 mo. = 22 mo.

$360. = Int. for 20 mo.
36. = Int. for 2 mo.
1.80 = Int. for 3 da. at 6%. (6 da. Int. is $3.60)
$397.80

If 5% is wanted: 6)$397.80 at 6%
66.30 at 1% (Subtract)
$331.50 at 5%

6)6 = 1 4)6 = 1½ 3)6 = 2 2)6 = 3.

Just add or subtract to get what you want.

No matter what the rate is, you have no multiplier larger than 2.

If the rate is 6% in a test, the average of the class is 50 problems in ten minutes.

Interesting Mathematics Forms

$$\frac{1}{3}\pm\frac{1}{5}=\frac{5\pm3}{5\times3}$$

$$\frac{7}{3}\pm\frac{7}{5}=7\times\frac{5\pm3}{5\times3}.$$

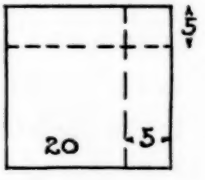
Use same method in algebra.
Numerator: $(x+3)+(x+2)$

$$\frac{1}{x+2}+\frac{1}{x+3}=\frac{2x+5}{(x+2)(x+3)}$$

$$\frac{1}{x+2}-\frac{1}{x+3}=\frac{1}{(x+2)(x+3)}.$$

Grade VIII. Easy Squares and Square Roots

$(20+5)^2$
$20+5$
$20+5$
$20^2+20\cdot5$
$+20\cdot5+5^2$
$20^2+2\cdot20\cdot5+5^2$ Still using the ten-system:
$t^2+2tu+u^2$



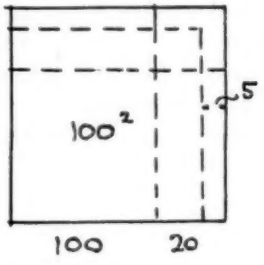
625)20+5 When you take out the t^2, you have the
400 band left.
This band is $2tu+u^2$.

40+5)225
225

That is the reason we double the t for a *trial* divisor.
Then they have $2t)\underline{2tu}$ where u is the width of the band.
u

If this does not come out even, the remaining bands can be put on. Here is a sample:

15625)125
10000
22)56
44
245)1225
1225



This helps the student to understand the square root.

Now the $t^2+2tu+u^2$ can be changed to
$a^2+2ab+b^2$ or any other square of a binomial.
The student sees at once the square of a binomial.

Note that we did not use any improper fraction in the arithmetic. Now we will throw them out of algebra.

(a) $\dfrac{x+1}{x+2}+\dfrac{x+2}{x+3}=3$ (Reduce to mixed numbers).

$1-\dfrac{1}{x+2}+1-\dfrac{1}{x+3}=3$. Or $\dfrac{1}{x+2}+\dfrac{1}{x+3}=-1$

$\dfrac{2x+5}{x^2+5x+6}=-1$. Then $x^2+7x=-11$.

(b) $\dfrac{2x+1}{2x-16}-\dfrac{2x-1}{2x+12}=\dfrac{9x+17}{x^2-2x-48}$

$1+\dfrac{17}{2x-16}-1+\dfrac{13}{2x+12}=\dfrac{9x+17}{x^2-2x-48}$ (Factor denominators).

$2(x-8)$, $2(x+6)$, $(x-8)(x+6)$.

Multiply by L.C.D. $2(x-8)(x+6)$.

Then $17(x+6)+13(x-8)=18x+34$

$17x+102+13x-104=18x+34$

$12x=36$ and $x=3$.

(c)
$$\frac{x+1}{x+2}+\frac{x+2}{x+3}=\frac{x+3}{x+4}+\frac{x+4}{x+5}$$

$$1-\frac{1}{x+2}+1-\frac{1}{x+3}=1-\frac{1}{x+4}+1-\frac{1}{x+5}$$

$$\frac{1}{x+4}-\frac{1}{x+2}=\frac{1}{x+3}-\frac{1}{x+5}$$

$$\frac{-2}{(x+4)(x+2)}=\frac{2}{(x+3)(x+5)}$$

$$\frac{-1}{(x+4)(x+2)}=\frac{1}{(x+3)(x+5)}.$$

Then $-x^2-8x-15=x^2+6x+8$

$\therefore \quad 2x^2+14x+23=0.$

In the long way, multiplying each numerator by the other three denominators, and collecting each side of the equation and you have:

$2x^4+26x^3+119x^2+223x+140=2x^4+26x^3+123x^2+251x+186.$

Or $-4x^2-28x-46=0.$

Easy Quadratic Methods

Any number multiplied by four times itself gives the square of twice the number.

e.g., $17\times17\times4=34^2$

$9x^2+8x=7$. Multiply by 9×4

9×4

$(18x)^2+2(18x)8=7\cdot9\cdot4$

$(18x)^2+2(18x)8+8^2=7\cdot9\cdot4+8^2.$

(This always gives the form $a^2+2ab+b^2$.)

$$\therefore \quad 18x+8=\sqrt{7\cdot9\cdot4+8^2}.$$

No matter what the numbers are, the only product work will be the part under the square root sign.

In algebraic complex fractions, use the same method developed in arithmetic. Just multiply by the L.C.D.

1. $\dfrac{\dfrac{x}{x+y}-\dfrac{x-y}{x}}{\dfrac{x}{x-y}-\dfrac{x+y}{x}}$ $(x+y)(x-y)x$ is L.C.D.

$$\frac{x^2(x-y)-(x+y)(x-y)^2}{x^2(x+y)-(x+y)^2(x-y)}=\frac{(x-y)(x^2-x^2+y^2)}{(x+y)(x^2-x^2+y^2)}=\frac{x-y}{x+y}.$$

2. $\dfrac{x}{x-\left(\dfrac{x+2}{x+2-\dfrac{x+1}{x}}\right)}$ (a) $=\dfrac{x}{x-\left(\dfrac{x^2+2x}{x^2+x-1}\right)}$ (b)

Multiply (a) by x and you get (*b*). Then multiply the lower part by x^2+x-1. (The L.C.D. of the lower part.)

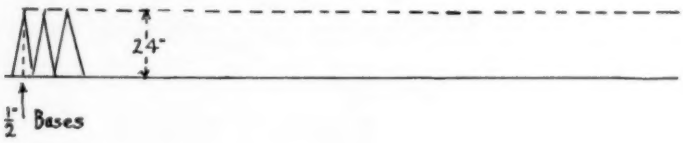
$$=\frac{x^3+x^2-x}{x^3+x^2-x-(x^2+2x)}$$ Reduce

$$=\frac{x^3+x^2-x}{x^3-3x}=\frac{x^2+x-1}{x^2-3}.$$

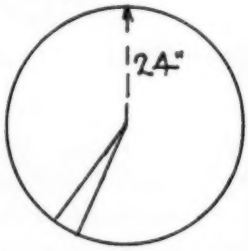
Circles: I studied with Professor Lindmann in Munich, the first man to prove that we cannot square a circle. I have only been about 200 decimal places. The other day I saw in a magazine that little subject carried to 707 decimal places.

Here is a comparison of polygons and circles:

Find the sum of the areas of 300 triangles having 24″ altitudes and $\frac{1}{2}$″ bases. The bases all in the same line.



Then fold up with all top points in the same point.



The area of each triangle is

$$\frac{24\times\frac{1}{2}}{2}=6.$$

The sum of the triangle areas is 1800.

If $R=24$ in a circle, $\pi R^2=1809.5516$.

Then compare the area of the triangles with the area of the circle.

Now we will work out a circle made of an infinite number of equal triangles:

π is the sum of the bases.

R is the altitude of the triangles.

Then $\pi D \times \frac{1}{2}R$ is the area of the circle.

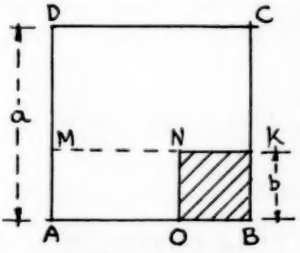
$\pi D \times \frac{1}{2}R = 2\pi R \times \frac{1}{2}R = \pi R^2$.

That is where we get our area formula.

Why does $a^2 - b^2 = (a+b)(a-b)$.

Area $DMKC = a(a-b)$.

Area $MAON = b(a-b)$.

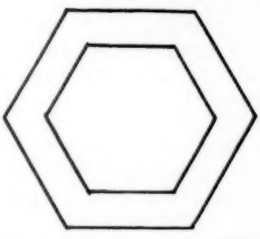


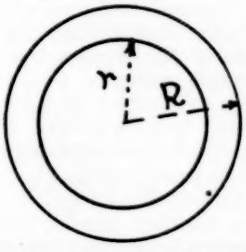
Add these equations and you have: $(a+b)(a-b) = a^2 - b^2$.

Then in circles, the band is

$$\pi R^2 - \pi r^2 = \pi(R+r)(R-r).$$

Area in a hexagon band is $3\sqrt{3}(x+y)(x-y)$.





Fun with exponents: $10^{.30103} \times 10^{.47712} \times 10^{.69897} = 10^{1.47712}$

$10^{.30103} = 2$. $10^{.47712} = 3$. $10^{.69897} = 5$.

Then 1.47712 is log of 30, or $2 \times 3 \times 5$.

Fun with odd numbers:

Sums 1, 3, 5, 7. 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, etc.

are |—|

Squares |———|

|—————|

|———————|

|—————————|

|———————————|

Sum of first two numbers is 2^2.

Sum of first three numbers is 3^2.
Sum of first four numbers is 4^2. $(1+3+5+7=16)$.
Sum of first nineteen numbers is 19^2 etc.
Sum of any set of numbers from 1 on is a perfect square.
Then:

$$S=\left(\frac{a+x}{2}\right)^2. \quad \text{Easy method.}$$

Sample: S from 1 to 23:

$$S=\left(\frac{1+23}{2}\right)^2=12^2.$$

That is the sum of the first twelve numbers in the series.

LIMA CONFERENCE PASSES RESOLUTION ON BEHALF OF W.F.E.A. CONGRESS AT RIO

Delegates to the recent Lima Conference paused in their deliberations to pass a resolution on behalf of the Eighth Biennial Congress of the World Federation of Education Associations to be held at Rio de Janeiro August 6–11. The resolution was approved Dec. 24, 1938, according to Dr. Paul Monroe, President of the W.F.E.A., and reads:

"WHEREAS: Recognizing the important role played by teachers and supervisors in the development in youth of appreciation of international understanding and good will, as well as the necessity that teachers and supervisors themselves shall have opportunities for increasing their own international knowledge and understanding; and appreciating the fact that the Eighth Biennial Congress of the World Federation of Education Associations to be held in Rio de Janeiro August 6 to 11, 1939, affords an unusual opportunity to gain such knowledge and understanding since it will bring together hundreds of teachers, supervisors and educational leaders from all American States to exchange in an atmosphere of friendship their common experiences and common concern for the well being of youth

"The Eighth International Conference of American States RECOMMENDS:

"(1) That the Eighth Biennial Congress of the World Federation of Education Associations, to be held in Rio de Janeiro August 6 to 11, 1939, be brought to the favorable attention of educational authorities and teachers in the American States.

"(2) That the attention of delegates be directed to the opportunity of visiting educational institutions in other countries en route to the Conference."

The *Rotterdam*, sailing from New York on July 5th and from New Orleans July 10th has been specially chartered to provide facilities for those attending the Conference, and further particulars may be obtained by writing to the headquarters of the Association at 1201 Sixteenth Street, N.W., Washington, D.C.

POSSIBLE TECHNIQUES FOR THE DEVELOPMENT OF SOME SCIENTIFIC ATTITUDES

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One who accepts as a possibly valuable outcome of his science teaching the development of scientific attitudes is faced immediately with the problem of directing his teaching methods so that his aim can be more or less attained. The authors of many scientific text-books seem naïvely to assume that the mastery of their material, factually presented, will be accompanied by mastery of the "scientific method" and the development of scientific attitudes. Psychologically, this seems an impossible outcome of more or less direct rote memorization.

As generally outlined the scientific method involves definite thinking about a problem with the end a tested idea or generalization. This obviously is diametrically opposite to the necessary acceptance of the idea or generalization presented by the text-book or teacher all too frequently without proof. Nor can this method of teaching (can it be called "educating"?) give opportunity for the development of the frequently cited scientific attitudes of suspended judgement, determination of causes of phenomena, ability to distinguish between cause and effect, etc. If these abilities are to be attained it will be only by the solution of problems. The word "problem" as used here is not to be subject to the frequent misinterpretation of all questions as problems for most problems represent difficulties usually unassociated with a question mark.

If practice in developing ability to think scientifically and maintain scientific attitudes is to be furnished students it will have to start with problems followed by thinking through to their solution with maintenance of the necessary attitudes. It is not to be expected that students at the beginning of a course in science will be able to think scientifically or even organize a method by which a scientific problem presented by experience may be solved. It would be the function of the teacher to serve in his position as an educator here and, by properly organized questions, to lead the class to organize its experiences associated with the phenomenon under consideration so that tentative solutions may be offered by the class, followed by plans by which the validity of each of the solutions may be tested, fol-

lowed by other problems to test the generality of the generalization. During this development of ideas care should be taken to maintain an attitude of suspended judgement, etc. With repetitions of this procedure will come greater ability on the part of the class to think in this manner so that one will begin to find students thinking ahead and asking some of the questions necessary in the solution. It is to be expected that if the problems answered have to do with features of the environment the students will gradually learn to answer similar problems when they meet them outside of the classroom. That this expectation is realized is shown by accounts given by students from some courses with which the author is familiar.

A difficulty with the use of the method of development is the necessity, if work out of class is to be assigned, that rather elaborate outlines for use by the students must be devised by the teacher if he would be sure that they will think as he wishes them to think or else a workable substitute must be used. One valuable device to give the students practice in using knowledge to extend knowledge and the teacher to learn how well members of the class are learning science consists in the assignment of selected objective problems. Two well-known examples are the true-false and multiple choice. These can be devised in such a manner as to demand the use of judgement by the students, an activity frequently uncalled-for in such problems. Under these circumstances the statement is a very real problem requiring the use of present knowledge in the solution with new knowledge and an increased grasp of the old as outcomes. The alternatives of the multiple choice type to call for real judgement must all seem to have some logical connection with the idea of the problem if maximum use of knowledge is to be demanded. (In the case of many examples of this type it will be found that the student can obtain the proper answer, without knowledge of the idea, by eliminating the alternatives which obviously have no connection.) If the assignment of problems includes the requirement that a clear, complete but brief outline of the reasoning through which the solution was reached, be submitted the pupil is given practice in accurate statement and the teacher obtains definite knowledge as to the thoroughness with which certain ideas have been grasped.

Two other types of objective problems devised by a committee of Wisconsin science teachers (see Ira C. Davis, *Science Education*, October 1935) may serve as those noted above with

the additional advantage that their use may serve to lead to better understanding of cause and effect relationships and practice in learning to distinguish between fact and theory. Examples of all four types mentioned are given with some comments at the end of this article.

These problems may be used in various ways for various purposes in teaching science. Frequently they may serve to provide an application step in the mastery of generalizations requiring genuine marshalling of ideas, and generally deductive thinking on the part of the students. In the solution of others so-called complete acts of thought will be necessary. In either case pupils will be learning to base conclusions strictly on evidence of *proved* ideas or facts. Dogmatic statements from text-books should not constitute proofs, a fact easily made obvious to students. This will not mean that the text-book will have no place in learning but does mean that the book should not be the supreme authority in all cases. (In fact it will be quite possible with many texts to show that some statements are not based on conclusive evidence; some are actually erroneous.) It will surprise some members of the class to learn that many unlabeled statements in the book are theories, that more than the generally accepted cause is operative in the production of a phenomenon.

Frequently these problems may serve to introduce conditions to be considered more fully in class at the next meeting, a particularly valuable feature in introducing fields inadequately presented by the book. The class should then approach the book, if it refers to it as an aid, with definite problems in mind and, with properly devised problems, see the significance of some statements emphasized by the problems. This understanding should lead to more intelligent participation in class discussions and to a more thorough, complete or usable set of ideas than those presented by the book.

An obvious fact but one perhaps worth mentioning is the availability of these problems for class discussion from which new ideas may be established, or as a means of motivating a complete study leading to a usable generalization.

One objection, frequently stated, to the developmental approach is that it is slow, its use requiring the elimination of parts of courses generally taught. The author does not want to argue that point though inclined to dissent unless it be agreed that the aim of a course is to teach as many items of information,

useful and usable or not, as time will permit. The objective questions, however, may serve as time savers if one needs to save time. Probably all will agree that there are many parts of a subject field so adequately presented in the text-book that they may be mastered by the class without aid of classroom discussion. Objective problems dealing with these portions will serve as definite motivation assignments, their answers as indices of student understanding and leave time for class discussion of the more difficult parts of a subject.

If one is concerned with developing in the minds of his class a broad field of understandings, and making these understandings in the broadest sense functional it appears necessary to make them functional by functioning. Of course this is the reason for the common method of developing the ideas or generalizations from consideration of the conditions and phenomena of the environment. By this means many ideas are "discovered" independently of the book and, indeed, reasons for abstract statements of the book are justified. The class, more or less as a unit, frequently thinks through to the answer of a problem—a generalization, it has practice in thinking without having attention called to the fact and its members, individually, may unconsciously adopt the method. Involved in this development will be, if the aims are to be approached, constant demand for suspended judgement, basing conclusions only on evidence, discrimination between cause and effect, fact and theory and limiting the ideas to the extent of the evidence.

So far as is known to the author no studies have been made to determine the effectiveness of techniques such as these as compared with the text-book recitation method or others. Students in courses known to the author in which the spirit is such as described earlier show considerable evidence of the attainment of functional understandings of the environment and development of scientific attitudes. Practically all students show great improvement in their ability to apply knowledge in the solution of problems in and out of class. Students who have difficulty in the beginning usually develop genuine competence and knowledge. Students who have thought through one or more courses commonly show increased competence in later courses. Unstudied statements by students serve to indicate that there is a definite "carry-over" by some into other fields of the habit of "looking to the record" for evidence in support of ideas met there.

To the teachers of one course encouragement for the continuation of the use of the methods suggested above has come from normal school graduates. Most of these are elementary school teachers of some experience which may have included attempts to answer the questions of children. Their gains in comprehension, scores on the same objective-subjective examinations as taken by college undergraduates and in appreciation are definitely greater than those of undergraduates. This seems to be true both in the concentrated work of the summer sessions and the diffuse work of extension courses. Almost unanimously these students voice appreciation of the definite understandings developed appearing to find a utilitarian value for class use in them.

Examples of typical problems chosen from several hundred devised for use in a course in general science, with brief comments follow: Naturally, all are not used in any one year.

TRUE-FALSE

1. The "Man in the Moon" is due to clouds on the face of the moon.
2. At time of total solar eclipse on the earth, from the moon the earth would be invisible.
3. Rivers have always flowed in their present courses.
4. The devices coupling the brake pedal to the brakes of an automobile have large mechanical advantages.
5. Days should be hottest at noon.

Assuming that the student has judged number 1 correctly to be false he faces the necessity of establishing the validity of his judgement. Statements that the effect is said to be due to surface irregularities or that books say the moon has no water would not be acceptable whereas ideas that clouds would suggest the presence of bodies of water producing glare in the sunlight would be acceptable. Similar types of evidence would be sought regarding statements presented by teacher or student during class discussion. A double purpose would be served by this method; habits of accepting validated ideas only and practice in the use of knowledge in new situations.

MULTIPLE CHOICE PROBLEMS

1. If the axis of the earth were not inclined to the plane of its orbit relative to January's, June's temperatures would be (a) cooler; (b) warmer; (c) identical; (d) one could not predict.
2. Relative to the speed of the earth in its orbit that of the moon is (a) greater; (b) less; (c) indeterminate; (d) sometimes greater and sometimes less.
3. When continental areas rise the direction of elevation is (a) vertical; (b) tilted; (c) with folding; (d) with faulting; (e) unpredictable in advance.

4. Energy is (a) heat; (b) work; (c) light; (d) sound; (e) all of the preceding.
5. As waves pass from one medium into another the unchanged factor is (a) wave length; (b) frequency; (c) energy; (d) velocity; (e) direction of travel.

It is believed that no comments are necessary on the above which would not be a repetition of those made earlier. Each requires the use of knowledge in a new situation unless the problem is used for review of ideas already established.

Cause-Effect Problems

These are judged according to the following "code" assuming contiguity or immediate sequence.

(a) The first is the sole cause of the second.
(b) The first is an important factor in producing the second.
(c) The first contributes slightly in producing the second.
(d) There is no causal relationship.
(e) Both are results of a common cause.

1. Igneous dikes: ridges on the surface of the earth.
2. Clear night: frost on grass following morning.
3. Rotation of the earth: "Horse Latitudes."
4. South-East winds: rain.
5. Retina: sight.

According to the code the first problem might be classified as "b" for while many ridges are due to erosion of rocks containing dikes probably more are due to differential erosion of inclined strata of differing degrees of hardness and other causes. Critical readers will find more than one interpretation possible according to the code in some of the examples. This is to be expected, of course, in many cases because of the degree of completeness of knowledge utilized in the judgement.

Fact-Theory Problems

Problems of this type are judged according to the following system.

(a) The statement is one of fact.
(b) The statement is generally accepted theory.
(c) The statement is a theory not accepted by all authorities.
(d) The statement is not confirmed by conclusive evidence.

1. A generator generates electricity.
2. The sun draws water.
3. Insulators are used in refrigerators to keep the cold inside.
4. Leaves are transformers of energy.
5. The flavors of fruits are due to minerals absorbed from the soil.

Statement 1 would, obviously, be classified under "d" for generators generate an electromotive force which, in a closed circuit, will cause electrons ("electricity") to flow. There may be at times difficulty in placement of statements under "b" or "c" which may be resolved by the teacher in the reasons given for the judgement. With this type of problem many surprises will come as students find on critical examination that statements apparently factual are really theoretical.

Problems of these types can be devised by any teacher interested in their use and to fit his particular circumstances. One will sometimes make oversights of debatable interpretations by students but experience will produce a high degree of efficiency. Of course if the problems are used for any purpose other than examinations no great harm can be done if there are points of disagreement which develop; indeed there may be a definite stirring of interest in the resulting class discussions. It must be expected that the problem will result in many questions from the class if it thinks about the problems so that the teacher must be ready to think himself out of difficulties at times. The fact that the class will think and ask intelligent questions will be found to be one refreshing outcome of the use of the methods suggested.

AS OTHERS SEE US

In a recent issue *The B. C. Teacher* comments as follows: "SCHOOL SCIENCE AND MATHEMATICS tells the science teacher—and the rest of us if we are listening—what to do when 'They Can't Read.' SCHOOL SCIENCE AND MATHEMATICS never smiles at you; it never puts on a smart frock or uses lip-stick; and it never flirts with its readers. These things I have learned from many years' familiarity; and all these things I regret. However, behind its severe and unpretentious covers you are safe to bet that there is always concealed an inexhaustible supply of valuable material fitting directly into the problems and situations faced by secondary school teachers."

The B. C. Teacher is doing an excellent piece of work in promoting the interests of education in the great region of western Canada. Because of its sincerity in all departments we highly value this appraisal.

OPPORTUNITIES FOR STUDY AT TEACHERS COLLEGE

Teachers College, Columbia University, announces a number of fellowships, scholarships and assistantships available for 1939–40. These will pay from $250 to $1,200 with extra amounts under certain conditions. Complete information and application blanks may be obtained from the Committee on Fellowships and Scholarships, Teachers College, Columbia University, New York City.

OUR GEOMETRIC ENVIRONMENT

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Primitive man had his first geometric training in his contact with nature. There he found fruits, flowers, shells and animals. To him nature was a vast museum with an endless variety of forms. A pool of water represented a plane surface, the sky suggested a hemisphere and the stars appeared as points of light. As the arts advanced he acquired a more technical knowledge of distances, areas and volumes, steps toward the science of geometry. Later he classified geometric figures as points, lines, angles, triangles, circles, etc., and came to regard them as the common phenomena of his daily experience. To-day it is common to use linear units in expressing the dimensions of lumber or cloth, in determining the size and shape of courts and fields used in sports and games. In surveying we express the linear dimensions of a tract of land or the elevation above or below sea-level. Linear units are necessary in building plans, in road construction, in map making, in expressing the score of a game or the velocity of light or of other ether vibrations. In industry, measurement is the tool which rules the world. The engineer, a past master in measurement, builds his dream of beauty—a bridge, a monument or a cathedral. When it is finished, it is strong and artistically proportioned. It is then that we frequently forget the measurements. However, they remain the bases of the strength and the beauty of the structure.

Combinations of lines forming parallels and perpendiculars are found in sidewalks, buildings and structural works of various kinds. Buildings are perpendicular to the ground plan. Forest trees, and raindrops on a still day, furnish illustrations of parallel lines without number. Sensibly parallel rays of energy radiating from a star or nebula are brought to a focus by the object glass of the telescope. The angle between this bundle of rays is increased by the eyepiece. This magnifies the object. In this way the number of known stars has changed from 5000 to 40 billion. Once the stars were regarded as mere points of light. Now they are known to be glowing masses of gas in some cases as much as 300 million miles in diameter. Once they were thought to be at a uniform distance of only a few miles. Now their distances are known to vary from 4.26 light years to 300

million light years. Whether we are measuring dry goods or the distance to a star the difference is merely a matter of the unit of measurement.

The angle which is common in all structural work and in rotating bodies, functions largely in explaining climatic conditions. During the winter season in the northern hemisphere the sun's rays strike that portion of the earth's surface obliquely. Within the Arctic circle the angle of incidence may be zero but it increases toward the equator where it is never less than $66\frac{1}{2}°$. At each point within the Torrid zone the rays are perpendicular to the earth's surface twice each year. The obliquity of the sun's rays determines quite largely the temperature, the quantity of light, etc., and therefore, the flora and fauna of the region. The temperature effect due to the obliquity of the sun's rays is very noticeable during the successive hours from sun up to sun down. The obliquity of the ecliptic $23\frac{1}{2}°$ accounts for the seasons and establishes the width of the zones, torrid, temperate, etc. The angular rotation of the earth on its axis is a factor in determining the direction of motion of a cyclonic storm, the equatorial bulge and the precession of the equinoxes. In geology the successive layers in veins of coal or sedimentary rocks are often good examples of parallel surfaces. In the case of a fault or an eruption, these layers may be found at any angle.

The triangle is also very common. It is found in the shapes of fields, in gable roofs, in surveys, in the deltas of rivers and in rigid structures such as bridges, autos and airplanes.

About 270 B. C., Aristarchus of Samos endeavored to find the relative distances of the sun and moon. Estimating the time when the moon was half full so he could use a right triangle, he measured the angle *MES* (see Fig. 1) and found it to be approximately 87°. This measurement indicated that the sun was 20 times as far away as the moon. From this, he reasoned that since similar solids are to each other as the cubes of their like dimensions, the volume of the sun must be 8000 times the volume of the moon. Although this measurement was greatly in error it gave a better idea of the relative size of the sun and moon, and pointed toward the heliocentric theory and a rational explanation of the solar system.

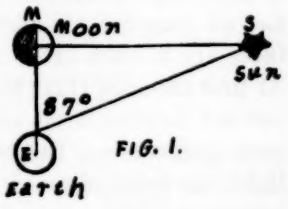

FIG. 1.

By measuring the obliquity of the sun's rays at different

points on the earth's surface namely, at Alexandria and at Assouan in Egypt, Eratosthenes (274–195 B. C.) came to the conclusion that the earth was spherical, and found that an arc of the earth's surface subtended by a central angle of $7\frac{1}{2}°$ measured 5000 stadia. His measurements indicated that the circumference was 250,000 stadia or 24,662 miles. From these data the earth's diameter was found to be 7850 miles which is only 50 miles less than the true polar diameter.

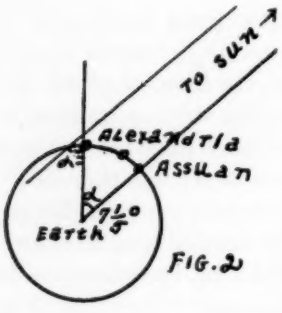

FIG. 2

Aristotle pointed out that an eclipse of the moon was caused by the moon passing through the conical shadow of the earth. Since this shadow on the face of the moon during the progress of an eclipse was circular, the earth must be spherical. Other arguments for the sphericity of the earth were based on the difference in the time of the beginning or ending of an eclipse as reported from India, Egypt or Spain.

These simple applications of geometry not only determined the shape and size of the earth with a fair degree of accuracy, but they emphasized a heliocentric theory for the solar system and gave a tremendous impetus to the idea of natural law.

In his investigations, Aristarchus made use of the right triangle. Eratosthenes used two geometric theorems; namely, "If two parallel lines are cut by a transversal, the alternate interior angles are equal," and, "In a given circle, the length of an arc is proportional to the central angle subtended by it." Let us consider an additional theorem, namely, "Similar surfaces are to each other as the squares of their like dimensions." At first thought this theorem seems to be very useless. It surely can not be compared with the Pythagorean theorem in its common applications. But when it is used to express the intensity of light, the force of gravitation or radiant energy, it says that the intensity varies inversely as the square of the distance from the source. Hence this geometric principle underlies the laws of falling bodies and projectiles, Kepler's laws of planetary motion and Newton's law of universal gravitation. These laws govern the heavenly bodies in their orbits, account for the tides, and play a part in the Chamberlain-Moulton theory of the origin of the solar system.

About 1912, Miss Leavitt of Harvard noticed that certain stars, called Cephid variables, pulsate in given periods and that all Cephid variables having the same period give off the same amount of light. These variables are very numerous, some being near and others in the most distant nebulae known. Since the distance to the nearest of these Cephids has been measured by geometric or trigonometric methods, it was possible by using the above principle to determine the distance to other stars far more remote. Consider a Cephid variable star which has been found by trigonometric methods to be at a distance of 100 light years and having a given period of variation. If a second Cephid, having the same period of variation as the first, is found to be $\frac{1}{4}$ as bright, then it must be twice as far away. If it gives 1/100 as much light it must be 10 times as far away, etc. By this method the distance to the Andromeda nebula, which may be seen with the naked eye, is fixed at 930,000 light years, and the distance to the farthest nebula known, at 300,000,000 light years. Hence this theorem, which too frequently has been considered a pure abstraction, was found by the astronomer in 1912 to contain the principle underlying the measurement of the known universe. When the great 200-inch telescope on Mount Palomar furnishes further data, this theorem will enable the astronomer to see at least 100 million light years beyond his present limitations in space.

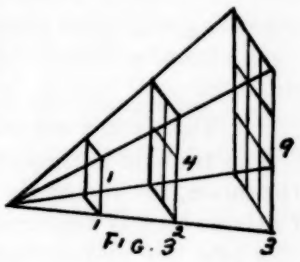

FIG. 3

More than three centuries ago, Kepler expressed his regard for such fundamental principles in these words:

> "Two things I contemplate with ceaseless awe
> The starry heavens and man's sense of law."

Pascal who states the matter differently, says: "Our sole dignity consists in thinking. Let us therefore strive to think correctly. That is the beginning of morality."

In such generalizations lie the ideas of oneness and order in creation, and of its revelation of beauty, so essential to science education. These laws indicate quite clearly that it is the mind of man which exalts him above all other forms of creation. Man's attempts to interpret the universe and his comparative greatness, are nicely expressed in the following lines:

"Great, wide, beautiful, wonderful world,
With the wonderful water round you curled.
. . . . . .
Ah! You are so great and I am so small
I can hardly think of you, world, at all.
. . . . . .
You are more than the earth, though you are such a dot,
You can love and think, and the earth cannot!"

The triangle is frequently used in obtaining the distance to the moon, the sun or the planets. A line from, say, Cape Town to Greenwich is measured. At a given time the angles between this base line and the lines of sight to the moon are measured. Having obtained two angles α and β and the included side AB of the triangle, the other two sides, and therefore the distance to the object is readily obtained.

A similar method is used to find the distance to the nearer stars. Let P (Fig. 4) be a very distant star and Q be a star whose distance is desired When the earth is at B, the angle QBP (β) is measured. Six months later when the earth is at A, the angle $QAP(\gamma)$ is measured. Then $\angle QBP(\beta) - QAP(\gamma) = \alpha$, which is the angle subtended at Q by the diameter of the earth's orbit, namely 186,000,000 miles. The distance QA is now readily computed. In the year 1838 this method was used to determine the distance to the nearest star, namely, Alpha Centauri, the distance being 4.26 light years. This method gives a very good degree of accuracy for distances up to 100 light years, and has been used to find the distance of stars up to 650 light years. Underlying a great many such measurements are very simple geometric relations which are easily and regularly proved by every student of tenth grade geometry.

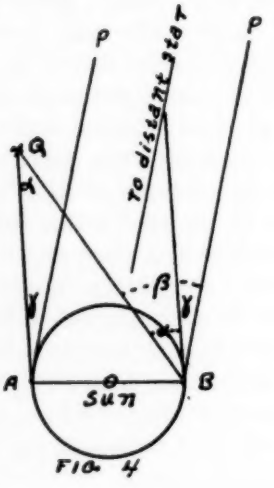

FIG. 4

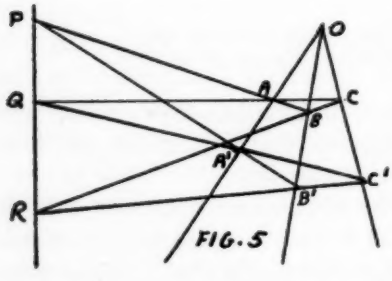

FIG. 5

In the trigonometry of the circle, where there are an almost untold number of applications, the triangle is basic. It is also fundamental in Desargues's theorem, namely: "If two triangles are perspective from a point they are perspective from a line."

This theorem is basic in drawing, in art and in architecture where perspective is wanted. Moreover, by this theorem alone, one can prove more geometry than is taught in the first semester of Euclidean geometry.

In art, according to Plato, the most beautiful triangle is the particular right triangle which is itself one-half of an equilateral triangle. From this triangle one can readily build the equilateral triangle, the rectangle, the parallelogram, the diamond (rhombus), and the regular hexagon, as well as three of the five regular solids, namely, the tetrahedron, the octahedron and the icosahedron.

In Japanese art there seems to be a preference for asymmetric forms based on the scalene triangle rather than on the purely symmetric forms. It is thought that in some cases the symmetric forms become tiresome. When form alone is in question, the equilateral or the isosceles triangle is usually preferred.

One reason for these geometric figures being so common in art is that there are only three regular geometric plane figures that will fill the space about a point, namely, the triangle, the rectangle and the hexagon. These figures in various combinations give rise to much that is beautiful in art, in the way of pleasing proportions, as well as balance and symmetry. Two of these figures, namely, the triangle and the rectangle, together with the circle, are probably the dominant geometric forms which arise in connection with every-day practical activities. The quadrilateral which includes the square, the rectangle, the parallelogram, etc., underlies much in architecture, in the division of land and in a great variety of sports and games. Among the quadrilaterals, the square is very common in art. Second only to the square is the "golden rectangle," whose length is 1.6 times its width. In Greek architecture, this ratio of the length of a rectangular panel or column to its width was kept constant, and called the golden mean. It is regarded as being one of the elements in making Greek architecture second to none even after 2000 years have passed.

The corresponding ratio of the major axis to the minor axis for the most artistic form of the ellipse is given as 5 to 3. This ratio which is 1.66, is almost the same as that of the rectangle.

The quadrilateral construction underlies perspective, a fundamental principle in art. The Figure 6 shows the geometric construction for drawing a ling through Q which will pass through the inaccessible intersection of l and l', thus giving perfect perspective. It is perspective that distinguishes the art of Leonardo da Vinci and other great painters from that of Asia and Egypt. In the latter countries, the art is flat and unattractive. In modern structures, any monument, bridge, cathedral or public building is a silent witness of the relations between geometry and architecture.

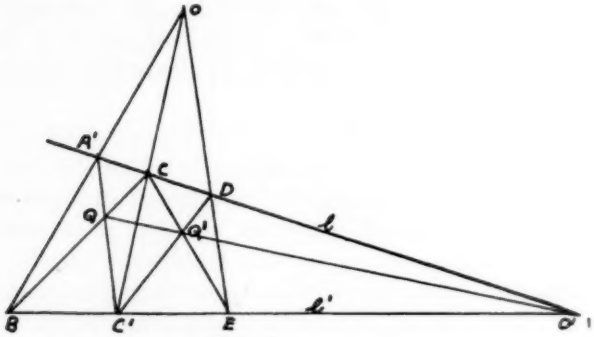

FIG. 6

The hexagon is very common in designs in architecture and art, besides it has a very large place in geometry, and in nature its uses are without number. The wasp constructs hexagonal cells in which it deposits its eggs. The honey bee makes use of hexagonal cells for storing honey. The cowfish is marked with shapely hexagonal designs, the hexagons being divided into well-marked triangles. Possibly the outstanding illustrations from nature are found in microscopic animal forms, the corals, the outer skin of the sponge and in the lovely snow flakes. The latter are always hexagonal. Nature is seldom so delicate, so lace like, so exquisitely beautiful as in the hexagonal snow crystal with their endless designs which defy verbal description. Here are the most ornate and intricate patterns conceivable. Each hexagon is different. Each is a part of the cosmic system in which the pupil finds himself. Should he be deprived of the opportunity of great art galleries, let him consider the snow flake, which for beauty of form, neither nature nor the art of man will ever excel. Nature is the supreme artist.

William Cullen Bryant pays his tribute with these words:

Snow

"Here delicate snow-stars out of the cloud,
Come floating down in airy play,
Like spangles dropped from the glistening crowd
That whitens by night the Milky Way."

One who pursues mathematics for the sake of mathematics is sustained by its charm and its potential richness. In this sense he is a poet indulging in the beauty of pure thought. A mathematician might well have written these words:

Frost

"He went to the windows of those who slept,
And overeach pane like a fairy crept;
Wherever he breathed, wherever he stept,
By the light of the moon was seen
Most beautiful things. There were flowers and trees,
There were bevies of birds, and swarms of bees,
There were cities, thrones, temples, and towers, and these
All pictured in silver sheen."

In geometry we have Pascal's theorem, namely: "The opposite sides of a hexagon inscribed in a conic meet in three points on a line."

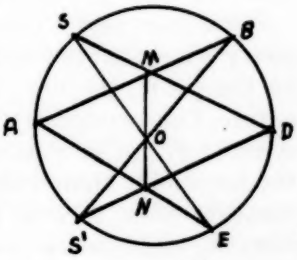

FIG. 7

This theorem was proved by Pascal at the age of sixteen, and later he deduced from it some 300 corollaries. The theorem is general and probably more comprehensive than the whole of the Euclidean geometry. Its proof is simple and short, but its power in mathematics is very great.

The five-pointed star of our American flag is based on a regular pentagon. In decoration, in clothing and in art, the circle is outstanding. Aside from the straight line and the rectangle, it is possibly the geometric figure most common. In mechanics are wheels, pulleys and the limb of a transit or telescope. In nature a tree or a stem when cut perpendicularly to its length is not only an approximate circle, but there may be hundreds of concentric circles. This is nature's way of recording the life story of the tree. If a stone is thrown into the water, concentric circles move outward. Radio and other ether waves radiate in a similar manner. The circular form is found in radials and rosettes among flowers. On a

photograph, the stars near the poles trace circular arcs. In the sky are the rainbows and the circles around the moon. The rainbow is sufficient evidence that color enhances the beauty of form. Then there are the planets, the moon, the sun and 40 billion stars. Were we to travel sufficiently into space, each of these bodies at a distance would present the appearance of a circle.

In art, the circle is given the highest rank since it is considered the most perfect figure. For this reason Plato argued that all of the heavenly bodies must have circular orbits. Although it was later found that circular orbits would not explain the successive positions of the planets, the idea was not given up until Kepler determined that the orbits of the planets were ellipses.

From the previous discussion, it will be seen that geometry has played a very large part in establishing the present ideas of the orderliness of the universe, the supreme discovery of science. It matters little whether you are considering the nest of the yellow warbler, the sun dogs, the rings of Saturn, or the great nebula of Lyra, there is a fundamental common geometric element, namely, the circle.

It has been said, "Beauty is a matter of symmetry and symmetry is a matter of form in geometry." Symmetric forms based on the point, the line, or the plane abound in both art and nature. Point symmetry is well illustrated by the circle, the line symmetry, but no point symmetry is seen in the triangle and the trapezoid. Plane symmetry is illustrated by passing planes through soilds, such as the cube, cylinder, sphere or cone. In fact, the child grows up with symmetric forms all about him. Bilateral symmetry is found in the external forms of most animals, in the leaves, in birds, in the snow flakes and the airplanes. This symmetry is very marked in the dragon fly with its wings of exquisite delicacy or in the wing spread of birds in flight. In the American hawks the bilateral symmetry due to the coloring is very striking especially when the hawks are in flight. Frequently residences and cathedrals exhibit bilateral symmetry.

Radial symmetry is found in the dandelion, the star fish, the Easter lily, and the snow crystal. Look for a spider's web. Notice its radial curves. These curves add to the beauty of the arch web of the spider.

The claim of pure mathematics to the attention of scholarly mankind is like that of art, in that it is grounded in the innate

human love of beautiful things and in the innate joy in originating them. Axial symmetry, which is fairly common, can be used as a tool for proving theorems in plane geometry. In mathematics, we often talk about spirals, the spiral of Archimedes, $\rho = a\theta$, the logarithmic spiral, $\rho = e^{a\theta}$. These spirals are very useful in engineering and construction work. In nature, we find the spiral in the budding fern fronds, in the tendrils of the sweet pea, in cones, and buds. The beautiful spiral forms found in the branching of trees, and in the shells which adorn the coasts are striking examples of a universal law. Probably the most common example of the spiral is the snail shell and the best example is the nautilus, or "The Chambered Nautilus," described by Oliver Wendell Holmes.

"Year after year beheld the silent toil
That spread this lustrous coil;
Still, as the spiral grew,
He left the past year's dwelling for the new,
Stole with soft steps its shining archway through,
Built up its idle door,
Stretched in his last-found home, and knew the old no more.
. . . . . .
Build thee more stately mansions, O my soul,
As the swift seasons roll!
Leave thy low-vaulted past!
Let each new temple, nobler than the last,
Shut thee from heaven with a dome more vast.
Till thou at length art free,
Leaving thine outgrown shell by life's unresting sea!"

The movement of the cyclone, the whirlwind, the tornado, and the water spout provides interesting illustrations of spirals. One of the very beautiful spiral nebulae of the heavens is catalogued as Messier 101. There are 2 million of these spiral nebulae within the range of the telescope. The one known was the Andromeda nebula is one of the grandest objects in the heavens. It is some 75,000 light years in diameter.

Before me is a beautiful suspension bridge. Its cables have the form of catenaries. This curve is common in the spider's web, the necklace, or in the flight of some birds.

The number of sepals, petals, and stamens in a given specie of flowers is commonly a given number or a multiple of that number. The triangular grouping is common in the Easter lily, the tulip or the dog-toothed violet; the quadrangular arrangement is found in the evening primrose; the pentagonal in the morning glory and the phlox; the hexagonal in the hyacinth and the tiger lily.

Among the solid geometric figures commonly found in nature are the cube, the rectangular prism, the pyramid, the cone, the sphere, and the ellipsoid.

When minerals grow freely they assume forms which are bounded by planes and the faces intersect in straight lines. These solids have the appearance of artificially made geometric solids and are known as crystals. Accurate and rapid identification of minerals can in many cases be most successfully made by recognizing the geometric form of the crystal. In minerals, the cubic form is found in the crystals of common salt, galena, native copper, silver, gold and the crystals of diamond. The quartz crystal is a hexagonal prism surmounted on either end by a pyramid. Some of the crystals are very beautiful and many of them are exceedingly common. Crystals emphasize the idea that nature is fundamentally geometric. The universal existence of geometric forms in nature led Plato to declare that, "God geometrizes eternally."

The sphere is illustrated by certain tiny seeds, by the balls used in games, the rain drops, or the great gaseous stars 300 million miles in diameter. Approximate spherical forms are sometimes found in the head of the dandelion, the Osage orange, or the pearls from the Mississippi River. The latter objects are sometimes quite perfect, and oh how beautiful! Then there is the spider's web jeweled with dew drops, glistening in the morning sun. In these forms, as in the snow crystals, nature has done her best.

> "The winds were still and the stars were bright
> And the fairies danced all night, all night,
> Then scattered in glee from their infinite store
> The sparkling jewels and gems they wore—
> Sapphires and rubies that gleam in the sun,
> Opals and pearls where their dancing was done."

The cone is common. We need to use a funnel. We see the cone of the pine tree, the volcanic cones, stalactites, and stalagmites, and in the shadow of the earth or moon during an eclipse. The pyramid is found in the quartz crystal. The oval is common in nuts, eggs, and flower buds. These illustrations indicate that the cultural value of geometry cannot be denied or ignored.

The child is born into a universe and is a part of the cosmic system. His environment in art, architecture and nature is strikingly geometric. The geometric approach is probably the simplest method of indicating that nature is not haphazard, is

not chaotic, that man is not governed by astrology and superstition, but that nature conforms to established laws, laws which frequently have a geometric basis. Witness the snow flakes, the mineral crystals, the concentric rings in trees, the spiral form in the tornado, or the shape of millions of the heavenly bodies. Natural laws are frequently expressed in terms of geometric ideas, such as, the law of falling bodies, the intensity of heat, light, or ether waves, univeral gravitation, and the laws underlying heredity.

Our environment constantly reminds us that geometry underlies much of art, of architecture and of natural law. The latter idea in its importance to the human race is second only to the idea of evolution. On the earth or in the stars are the same chemical elements, the same geometric forms, and the same fundamental laws. Whether we deal with the fields, flowers, the crystals, art, architecture or the heavenly bodies, the geometric element is not wanting. Our environment is strongly geometric.

A METHOD FOR PHOTOGRAPHING BIRDS

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During the course of a recent study of plumage variations it was found necessary to photograph a number of birds. Prints were desired that would reproduce well and be suitable for an analysis of the plumage with respect to the detail and relative intensities of various parts of the pattern. The large number of photographs to be taken made an inexpensive method essential. Snapshots made with an ordinary camera with a portrait attachment were unsuitable because of their small size and lack of contrast; to overcome these difficulties the arrangement described below was devised.

Photographs were taken with an Eastman Folding Kodak (No. 116) using the front lens (focal length about 11 in.) of a doublet lens system of another camera as a portrait attachment. With this arrangement an image one-half natural size was obtained. It was necessary to place the camera about 10 inches from the object to be photographed in order to secure the proper focus. The camera was mounted on one end of a 2 in. by 4 in. by 18 in. board. An upright board, 7 in. by 9 in. by $\frac{1}{4}$ in., was

mounted with a wood screw on the other end of this base in such a manner that its distance from the camera could be adjusted. A hard-finished white paper was fastened to the upright to serve as a background; a small block of wood was attached to hold a card on which was printed the band number of the bird being photographed. Using a ground glass plate on the back of the camera the upright board was adjusted so that a bird held against it would be in sharp focus. An outline of the field visible in the glass plate was traced on the background to facilitate placing birds so as to be centered in the photograph. A tin shield with an opening in the center $1\frac{3}{4}$ in. high by 2 in. wide was cut to fit in the back of the camera just in front of the film. The edges were crimped to prevent scratching the film and the shield painted a dull black on both sides. It was found

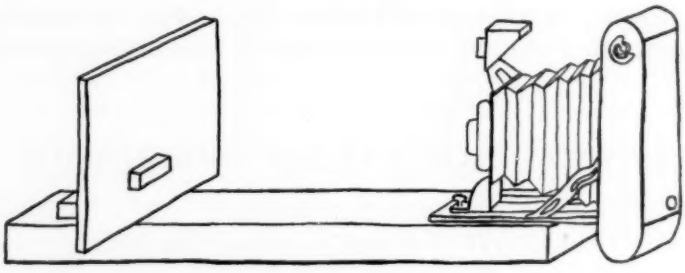

FIG. 1. Arrangement for photographing birds with an Eastman No. 116 Kodak.

that one revolution of the film spool carried an exposure just past the opening in the shield making it possible to take three exposures on the amount of film ordinarily used for one picture. Special lighting was required in order to obtain prints of uniform intensity and without shadows; a General Electric Mazda Photoflood bulb in a reflector was placed on each side of the camera at a distance of 18 in. from the background. Eastman Super Sensitive Panchromatic film exposed for 1/50 of a second gave excellent contrast. For photographing the bird was held by the legs and beak and placed against the background; the shutter was snapped by an assistant. Although this arrangement has been applied only to bird photography it appears that it could easily be adapted to photographing any small objects such as insects, flowers, etc.

A MULTI-USE PHOTOELECTRIC CELL SET UP

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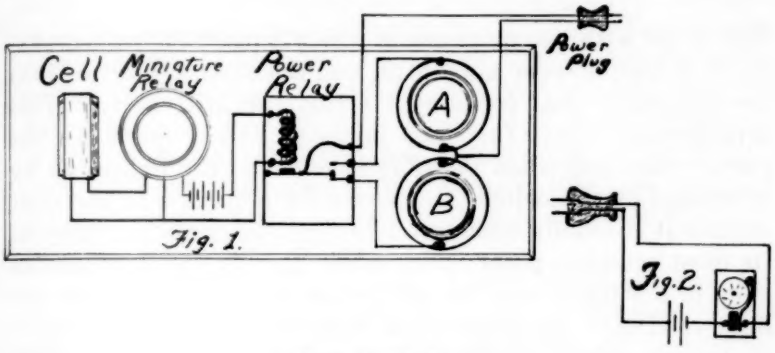
The photoelectric cell and relay apparatus lends itself readily to many interesting uses and provides a striking method of demonstrating the concept of light as a form of energy. The apparatus can be used most effectively if all of the items are securely mounted on a board. For convenience the output of the power relay is fed into two ordinary lamp sockets labelled A and B as in Fig. 1. When lamps are placed in the sockets and the



FIGS. 1 AND 2.

plug connected to a power circuit the apparatus is ready to function normally. If light falls on the cell, the circuit feeding lamp A is closed and it lights up. If the light is interrupted, lamp A goes out and the circuit feeding lamp B is closed and it is illuminated.

To increase the range of usefulness without changing the wiring it is only necessary to substitute receptacles for the lamps and short circuit the exposed prongs of the power plug. Under these conditions any self powered equipment plugged into receptacles A or B will be turned on or off at the will of the operator who controls the light. (A flashlight makes an excellent source of light for actuating the cell.) Figure 2 shows a suggested set up for controlling a bell or buzzer.

Perhaps the most spectacular use of this apparatus is that of controlling the lights of any room in which it is placed. This can be accomplished at small cost and with little difficulty in the following manner:

A receptacle or socket is shunted across the switch that controls the lights of the room. This is shown in Fig. 3. An extension long enough to reach from a window to the switch is

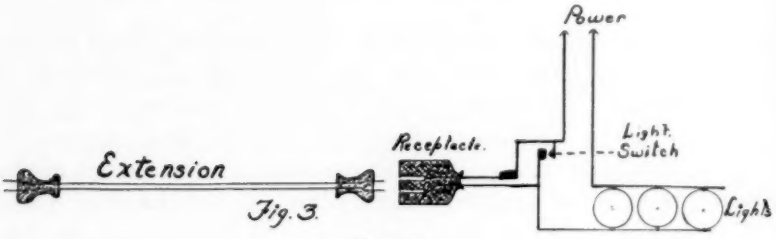


FIG. 3.

then fitted with two plugs one of which is inserted into receptacle B of the photocell apparatus, and the other is inserted into the receptacle that is shunted across the light switch. This arrangement allows the room lights to be controlled by the power relay and when the plug is removed the lights can be controlled by the switch. To operate the apparatus in this connection it is usually necessary to adjust the miniature relay to its most sensitive point. Then place the photocell apparatus close to a window with the cell facing the window. Should the light coming in the window fall below the value necessary to operate the relays, the light circuit will be closed and the lights will go on. On bright days the light from the window falling in the cell actuates the relays which shut off the lights.

We found that the relay combination was so sensitive that it shut off the lights on dull days, so it was necessary to shield the cell with one layer of thin tissue paper. Under these conditions the lights were turned on, when the illumination in the darkest corner of the room fell below 12 foot candles. In other situations it will be necessary to experiment both with the adjustment of the relay and the shield or hood for the cell.

It is always interesting to note the start of surprise that occurs when the lights go on automatically, thus emphasizing the ability of the human eye to accommodate itself to wide ranges of light intensity without the person noticing any change until strain has developed. This demonstration not only clearly illustrates the photoelectric property of light but also serves to develop in the mind of the student a consciousness of the necessity of adequate lighting.

COMPARISON OF GRADES IN COLLEGE TRIGONOMETRY BETWEEN STUDENTS WHO HAD THE HIGH SCHOOL COURSE AND THOSE WHO DID NOT

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College teachers of trigonometry have often been heard to remark that they prefer that their students had not had the subject in high school. They maintain that the first few weeks of both the college and high school courses contain much the same material, namely, the introduction to and familiarization with the new terms and procedures. Thus the college student who has had the high school course finds those first few weeks rather easy, develops a lazy attitude, and then becomes lost before he can recover when the more advanced theoretical work is begun. These teachers feel that the course has its place in the high school for students who do not intend to take it in college, but that those who do not take it in high school will be better off when taking it in college.

In an attempt to discover just how much foundation there is for this objection the writer has compared the grades in college trigonometry of 119 students who had the high school course with the grades of 122 students who did not have the

COMPARISON OF GRADES MADE IN COLLEGE TRIGONOMETRY

Grade	*Group I*		*Group II*		Total
	Students Who had High School Trigonometry		Students Who did not have High School Trigonometry		
	Number	Per Cent	Number	Per Cent	
A	23	19.33	7	5.74	30
B	22	18.49	17	13.93	39
C	41	34.45	43	35.25	84
D	18	15.13	26	21.31	44
E	12	10.08	19	15.57	31
Drop	3	2.52	9	7.38	12
Inc.			1	0.82	1
Total	119	100.00	122	100.00	241
Grade Pts.	2.22		1.70		

high school course. Before beginning it was his natural guess that the students with the high school training would do much better especially since the high school course, in general, would have been elected only by those students who had found mathematics easy or interesting to them.

All of these 241 students were enrolled in the Morgan Park Junior College under three different instructors. All of them took the same course regardless of previous training.

The table shows the comparison of grades made by students in college trigonometry between those who had high school trigonometry and those who did not. Those who had the high school course will be referred to as Group I, the others as Group II.

Of the students in Group I 19.33 per cent received 'A' grades. This is very high compared with the 5.74 per cent for those in Group II. These of course are the excellent students who very likely would have received high grades regardless of whether or not they had had the high school course.

The per cents of students in the two groups receiving 'B' grades are somewhat more even, 18.49 per cent for Group I, 13.93 per cent for Group II. The two groups are quite even for the 'C' grade, 34.45 per cent for Group I as compared with 35.25 per cent for Group II. Certainly there is not a very large difference in achievement between the two groups for the better grades.

For grades below 'C' Group I is not very much better than Group II. Grades of 'D' were received by 15.13 per cent of the students in Group I, and by 21.31 per cent of those in Group II. It is astonishing that 10.08 per cent of the students of Group I failed the course and that an additional 2.52 per cent dropped it (students usually drop the course because they find it too difficult). Compared with these figures are 15.57 per cent failed and 7.38 per cent dropped in Group II. The achievement of students in Group I is better than in Group II, but not as much better as would be expected.

The last line of the table shows the average grade points for each group. An 'A' grade has been counted as four points, a 'B' as three points, a 'C' as two points, a 'D' as one point, and and 'E' as zero. The average for Group I was found to be 2.22, slightly better than 'C.' The average for Group II 1.70, slightly less than 'C.' There is not an appreciable difference between the two groups.

THE USE OF ELEMENTARY METHODS IN CHEMISTRY

WM. E. FISHER
High School, Bonner Springs, Kansas

Perhaps some of you can remember as clearly as I those first few days or weeks of teaching. For my part I am quite certain that my most vivid recollection will always be the utter shock I received when I came to realize how little the boys and girls intrusted to my care actually knew. Many would-be teachers never receive this shock and consequently fail. They go blissfully on for a year or perhaps even two or three, pouring out high sounding theories and formulas, high over the heads of their students, in a vocabulary as far advanced for their listeners as back-bay Bostonian would be for a Tennessee mountaineer.

No doubt the mistakes on your first set of examination papers were almost as atrocious as those on mine. One little boy informed me that, "The atmusfear is composed out of oxigon and nightrigen." Few are the beginning students I have met who have enough pride or initiative to add the multitude of new scientific terms to their vocabularies in anything resembling a correct spelling or with more than a very hazy idea of the true meaning of the term. Ever since that first set of examination papers we have set aside some time in my science classes for a drill on vocabulary, both in spelling and in defining the new terms of scientific meaning that are most apt to find a place in every day use.

Much of the subject matter in science courses is new to students. Some of it is very foreign to their former fields of thought and activity. Particularly is this so in chemistry. Therefore, I feel that adaptations of certain elementary methods can be very well adopted in chemistry.

It is one of these methods which I want to pass on to other chemistry and science teachers.

Do you remember those "flash cards" back in the lower grades and how the teacher would hold up cards showing, CAT, or RAN; $7-3$, or 4×8? We use just such flash cards in my chemistry classes. Sometimes we use them for drill, sometimes just for fun. (I sometimes wonder if we don't accomplish more when we use them for fun than we do when we use them for

drill.) I have quite a stack of cards, 4″×7″, each of which shows chemical formulas ranging from O_2 up to $NaKC_4H_4O_6$ printed in heavy black crayon.

Early in the year we begin to use the simple ones in order to acquaint ourselves with the "chemists' shorthand." Later on after we know more about symbols, formulas, equations and how to name the compounds properly we use them more and more.

To the uninitiated there is slight difference between HgCl and $HgCl_2$, but to the chemist what a vast difference actually exists. The chemist knows HgCl to be mercur*OUS* chloride, our friend calomel, a helpful internal medicine. At the same time he recognizes in $HgCl_2$, mercur*IC* chloride, a deadly poison, corrosive sublimate. ClO is a *hypo*-chlor-*ite;* ClO_2 a chlor-*ite;* ClO_3 a chlor-*ate;* and ClO_4 a *per*-chlor-*ate*. Each is prepared differently; each has different properties and different uses. I firmly maintain that students, even high school students in beginning chemistry, can and should be taught to name them easily and correctly. To this end we drill with these flash cards, sometimes in unison, sometimes in rotation around the class, or in written lessons. We drill not only on naming the formulas but we reverse the process and learn to write the formulas correctly when the substances are named. On some occasions we make a game of the whole affair and present the student with the card once the formula has been correctly named. Even the most serious high school seniors will enter into competition of this sort with the keenest interest and rivalry to secure the greatest number of cards. Competition has run very high in some of my groups.

But this is not the only use to which these cards can be put. By securing a board with grooves in the front (similar to the board hanging in front of the Sunday School setting forth the attendance, collection, etc.) these cards can be arranged and rearranged to form equations representing chemical reactions of all kinds. It always seems to me that students take a keener interest in searching through a small pile of cards and fitting the correct one on this board than in merely writing the equation on the black board. (Of course it is up to the teacher to see that the pile is not large enough to consume unnecessary time and that the correct card is there.)

Later in the year after a wider field of knowledge has been acquired we put these cards to a broader use. The teacher

presents a certain card to a pupil and to obtain it the pupil must not only name it but must state some fact relating to it as requested by the teacher. These facts may be the occurrence, the preparation, the principle properties, the chief uses, or the like. Doubtless enterprising teachers can find other and perhaps more varied uses for cards of this kind.

In conclusion, then, since chemistry is just as new to high school students as the "three R's" are to primary graders I am certain we are not only justified for, but also benefited from using many elementary methods.

THE PLANE MIRROR EXPERIMENT

GLEN W. WARNER
Woodrow Wilson Junior College, Chicago, Illinois

The plane mirror experiment is one of the simplest in the year's work in physics. The apparatus is cheap; it requires practically no storage space; it is entirely an individual problem for each student. But the results are often disappointing. Many pupils have not previously learned to line up a pin with another one and the image of a third, or a straight edge with the image of a pin. This then becomes a skill to be developed in this exercise. But the chief trouble is that honest students cannot check the law given in the text. Most manuals give specific directions for placing the mirror edge on a sharp line which represents the mirror in the drawing, but they fail to point out that the refraction of the light in the glass, even though the glass be thin and the effect small, is still appreciable. Of course the students have not yet taken up the study of refraction, but the phenomenon and its effects are present in the experiment. A cure for this ill is to use mirrors that do not refract the light; i.e. mirrors with the mirror surface in front. Very satisfactory chrome plated steel mirrors can now be obtained just as cheap as the silvered glass ones.* These glued to a supporting block of wood will not break if dropped, do not scratch or tarnish easily, and eliminate that little irritation caused by refraction.

* If your apparatus dealer does not list such mirrors they may be obtained in any size desired from the Apollo Metal Works, 6650 Oak Park Avenue, Chicago, Ill.

Sometimes this experiment is made so easy that it is quite trivial and strong students get the impression that it has no value. A few questions which bring out the facts developed by the experiment will try the mettle of the best high school students and give seventy-five per cent of the college freshmen or sophomores something for their time. The author has used this experiment as an approach to the study of light, demanding in the report only good constructions and answers with reasons or proofs to the questions below. The results are satisfactory because thinking is demanded, outside experimentation stimulated, and correlation with the work of the geometry class is effected.

Questions on the Plane Mirror

1. Make a drawing of an arrow in front of a plane mirror and oblique to it. Construct the image of the arrow using the law developed in the experiment.

2. Is your image in a plane mirror exactly like your photograph in the way it depicts your position and appearance? Explain. (Note: Do not permit students to ramble off on a discussion of the camera and what the lens does; focus attention on the finished products—mirror image and photograph. To illustrate have one pupil face two others, one of which is to act as the image and the other as the photograph, while the first takes different poses. Secure two photographs exactly alike. Place one facing the other and a mirror to form an image of the first so that the second photograph and image will be adjacent to each other.)

3. What must be the height of a plane mirror in order that you may see your entire image? Assume the mirror to be perpendicular to the floor and at any distance above the floor. (Note: Solve by a visit to the local shoe or clothing store if no full length mirror is available in classroom or home. Let the pupil stand at various distances from the mirror and cover the bottom of the mirror with a piece of cardboard or news-paper just high enough to permit him to see the tips of his toes. Mark this point on the mirror with soap. Repeat the procedure at the top of the mirror moving the screen down until the top of the head is just visible by the subject. Measure the distance between soap marks. Check the answer by a geometrical construction and proof. Some students may prefer to attack first by the geometrical route. Science uses both plans.)

A COMPARISON OF A "ONE-HOUR TWO SEMESTER" AND A "TWO-HOUR ONE SEMESTER" COURSE IN BIOLOGY

PAUL E. KAMBLY
University High School, Iowa City, Iowa

During the school year of 1937–8 the writer had the opportunity of teaching biology to two groups of pupils for two hours a day for a semester only, as contrasted to the usual plan of one hour a day for a full year. These pupils spent two hours a day in world history during the semester in which they were not taking biology. At the end of the year they had the same credit for high school work as they would have had they taken these two subjects one hour a day for a full year. This paper is a discussion of this time arrangement as it applied to the biology classes.

For several years it has been the practice to give a pretest to all science classes beginning work in the University High School. Since the fall of 1934 the test used for biology classes has been the 1934 Iowa Every Pupil Test in Biology. This same test has also been given at the end of the year as a section of the final comprehensive achievement test. Consequently, it was possible with these scores to make a direct comparison of the results obtained under the two plans of course organization described above.

The validity of the comparison rests on the facts that the groups were of comparable ability and were taught by the same individual. No assumptions of exactly similar approaches to all topics or the same order of presentation may be made. During the time spent in the biology classroom, however, pupils under both plans were introduced to essentially the same biological subject matter.

The forty-two pupils who took biology during the 1937–8 school year in two sections are treated as one group in this discussion. The comparable group under the two-semester plan was taken from the 1934–5 classes. The two-semester pupils were so selected that their average score on the pretest was the same as that of the forty-two one-semester pupils, and so that the standard deviation of their scores was approximately the

same as that of the latter group. These measures are given in Table 1.

TABLE 1

COMPARISON OF PRETEST SCORES FOR THE ONE-SEMESTER AND TWO-SEMESTER GROUPS

	Number of Pupils	*Mean Score*	*S.D.*
1934–5 (Two-sem.)	42	41.69	12.74
1937–8 (One-sem.)	42	41.69	11.76

At the end of the course, each group was tested again by the same examination which had been used as a pretest. The means and standard deviation of the distribution of these scores are given in Table 2.

TABLE 2

COMPARISON OF FINAL TEST SCORES

	Number of Pupils	*Mean Score*	*S.D.*	*Difference in Means*	*S.E. of Difference*	*Significance Ratio*
1934–5 (Two-sem.)	42	83.58	11.25	5.56	4.82	1.15
1937–8 (One-sem.)	42	78.02	14.22			

Since a significance ratio of three or more is necessary to indicate a statistically significant difference, it is obvious that the difference in mean scores for the two groups may be readily attributed to chance. In other words, there is no conclusive evience that either plan of presentation is superior to the other. While the probability favors the two-semester plan, it is quite possible that equally good results can be secured under the one-semester plan.

Pupil reaction toward meeting two hours a day was generally very favorable. Their chief argument in favor of the arrangement was that they had only three subjects to work on rather than four. This was considered to be an advantage by both advanced and retarded pupils.

From the teacher's viewpoint the long period was an advantage in that it offered the opportunity for longer field trips, and uninterrupted experiments and study periods. The teacher was allowed to give the pupils a five-minute intermission at any

time during the period. Consequently classroom procedures were not interrupted by the bell. The chief disadvantages of the plan appeared to be: 1. There was a marked tendency on the part of the pupils to waste time because they felt they had plenty of time. 2. All materials used in teaching biology to the forty-two pupils had to be assembled twice during the year rather than once. 3. The irregular five-minute intermissions caused some disturbance for classes in session.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solution should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1568, 69, 70. *Fred Marer*

1579. *Kenneth P. Kidd, Gainesville, Fla. Walter R. Warne, Minneapolis.*

Interesting Solution to 1563

Mr. I. N. Warner, Platteville, Wisconsin, sends in two very interesting solutions to problem 1563. Since the approach is more arithmetic in nature than the published solutions in the recent December issue, they are given.

If the center of this square field be connected by straight lines to each extremity of every panel of the fence, then the field is separated into equivalent triangles, each of four acres. By simple arithmetic the altitude is found to be 31,680 feet. The side of the square is double the altitude. From this the area of the triangle is readily found.

Also suppose that all of the boards from three sides of the square field

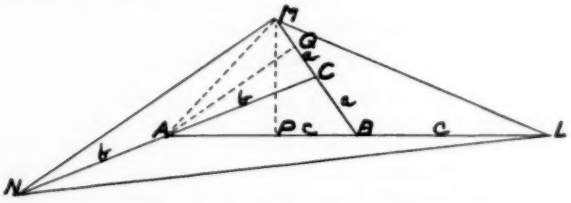
be equally distributed among the several panels along the fourth side. Hence for each eleven foot panel there are sixteen acres. The field may then be divided into sixteen acre rectangles, each eleven feet wide. The length of each rectangle which is the side of the square is easily found.

1580. *Proposed by Hugo Brandt.*

In triangle ABC, produce AB to L, BC to M, CA to N so that $BL=AB$, $CM=BC$, $AN=CA$. If ABC has an area of F, prove that triangle LMN has an area of $7F$.

First Solution by Ralph Brown, Jackson Heights, Long Island, N. Y.

Draw AM and the perpendiculars AQ and MP. Triangles AMC and ABC are equal, since MC equals BC, and AQ is common. Hence triangle ABM equals twice triangle ABC, or $2F$.



But triangles LBM and ABM are equal, since LB equals AB, and MP is common. Hence triangle LBM equals $2F$. Similarly, triangles MCN and NAL each equals $2F$.

Now triangle LMN equals the sum of triangles ABC, LBM, MCN, and NAL. Therefore, triangle LMN equals $7F$.

Second Solution by Lester Dawson, College, Alaska

From the given figure and from trigonometry, using the notation in the figure, Area of $\triangle ABC=F=\frac{1}{2}ac\sin B=\frac{1}{2}bc\sin A=\frac{1}{2}ab\sin C$.

Also, from the figure, and from trigonometry,

$$\begin{aligned}\triangle LMN&=\triangle ABC+\triangle MCN+\triangle BLM+\triangle ANL\\&=F+ab\sin(180-C)+ac\sin(180-B)+bc\sin(180-A)\\&=F+ab\sin C+ac\sin B+bc\sin A\\&=F+2F+2F+2F\\&=7F.\ \text{(by substitution)}\end{aligned}$$

Third Solution by Arthur Danzl, Collegeville, Minn.

Without loss of generality, the vertices of triangle ABC may have as coordinates, $A(a, 0)$, $B(0, 0)$, $C(b, c)$. The vertices N, M, L of triangle LMN will then have as coordinates, $[(2a-b), -c]$, $(2b, 2c)$ and $(-a, 0)$ respectively.

$$\text{Area of } \triangle ABC=\tfrac{1}{2}\begin{vmatrix}0&0&1\\a&0&1\\b&c&1\end{vmatrix}=\tfrac{1}{2}ac=F$$

$$\text{Area of } \triangle LMN=\tfrac{1}{2}\begin{vmatrix}2a-b&-c&1\\2b&2c&1\\-a&0&1\end{vmatrix}=\frac{7}{2}ac=7F.$$

Solutions were also offered by Fred Marer, Los Angeles City College, W. R. Smith, Chicago, Carrie G. Webb, Coffeyville, Kansas, Kenneth P. Kidd, Gainesville, Florida, Hazel C. Jones, Danville, Ill., Cecil Leith, Scituate, Mass., M. Kirk, West Chester Pa., Winfield M. Sides, Andover, Mass., Sulamith Bereskin, Sioux City, Ia., Sidney Cabin, Brooklyn, N. Y., O. L. Dunn, Vincennes, Ind., Charles W. Trigg, Los Angeles, S. E. Field, Ironwood, Mich., Fred A. Miller, Newell, W. Va., Lawrence R. Schoenhals, Huntington, Ind., J. V. Bernando, Plainville, Conn., W. R. Warne, Minneapolis, John N. Meighan, Harpers Ferry, W. Va., also by the proposer.

1581. *Proposed by Norman Anning, University of Michigan.*

Reduce to lowest terms $\frac{1234567.5}{3456789}$.

Solution by I. N. Warner, Platteville, Wisconsin

First multiply each term of $\frac{1234567.5}{3456789}$ by 2 to change to simple form. Then the following principles applying in all such examples, will suffice:

1. Factor either term alone.
2. Factor difference of terms.
3. Factor sum of terms.
4. Use Euclid's Algorithm for finding highest common factor.

Simple form of fraction is $\frac{2469135}{6913578}$.

Difference of term is: 4444443. Dividing by 9, we get: 493827. Trying 493827 upon each of terms, we find it contained in numerator 5 times and in denominator, 14 times.

Hence in lowest terms, given fraction is $\frac{5}{14}$.

The Euclidean method also reveals 493827 as highest common factor of the two terms of the simplified fraction. It may be added, that these methods also apply equally well in Algebra.

Solutions were also offered by Fred Marer, O. L. Dunn, Vincennes, Indiana, Hazel C. Jones, Danville, Ill., Cecil Leith, Scituate, Mass., Sidney Cabin, Brooklyn, N. Y. Charles W. Trigg, Los Angeles, S. E. Field, Ironwood, Michigan, Fred A. Miller, Newell, W. Va., Ralph Brown, Jackson Heights, Long Island, N. Y., W. R. Warne, Minneapolis, Minn., John N. Meighan, Harpers Ferry, W. Va., W. R. Smith, Chicago, also by the proposer.

1582. *Proposed by Aaron Buchman, Buffalo, N. Y.*

Two straight roads intersect at right angles. A sign which is r feet long is placed along one road at a distance of m feet from the intersection. Without the use of calculus, find the point on the other road at which the sign subtends the greatest angle, that is, the best point from which to view the sign.

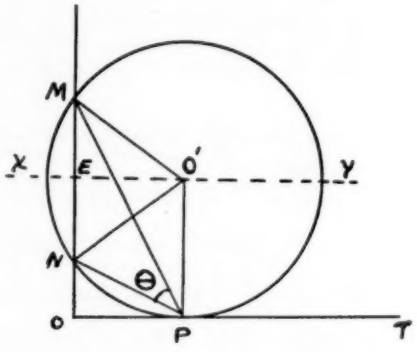
Solution by Winfield M. Sides, Phillips Academy, Andover, Massachusetts

Take $MN = r$ and $ON = m$. Assume $OP = x$.

Let O' be the center of the circle drawn through the points M, N, and

P. The perpendicular bisector of MN is the locus of center O' of the circle through points M and N.

A decrease in the radius of circle O' causes an increase in $\angle MO'N$, and in result the degrees in the minor arc MN increases, and therefore $\angle\Theta$ increases.



The smallest circle having its center on XY and a point in common on OT is the circle tangent to OT. Consequently the location of P making the circle O' tangent to OT gives the best point from which to view the sign, that is $\angle\Theta$ a maximum.

For the location, find the mean proportional between ON and OM and strike it off from O along OT to find the point P.

$$OM:OP=OP:ON$$

or
$$r+m:x=x:m.$$

and
$$x^2=m(r+m),$$

$$x=\sqrt{rm+m^2}.$$

Solutions were also offered by Fred Marer, Kenneth P. Kidd, Gainesville, Fla., M. Kirk, West Chester, Pa., Sidney Cabin, Brooklyn, N. Y., O. L. Dunn, Vincennes, Ind., Charles W. Trigg, Los Angeles, Norman Anning, University of Michigan, Fred A. Miller, Newell, W. Va., Ralph Brown, Long Island, N. Y., J. V. Bernardo, Plainville, Conn., W. R. Warne, Minneapolis, Minn., and also by the proposer.

1583. *Proposed by Norman Greenspon, Brooklyn, N. Y.*

Find the number of terms in the expansion $(a+b+c+\cdots$ to n terms$)^p$ expressed as a function of p and m.

Solution by Boris Garfinkel, Buffalo, N. Y.

Since each term of the expansion is of the degree p, the number of terms equals the number of ways p can be expressed as the sum of n positive integers.

Consider p identical objects distributed among n compartments separated by means $n-1$ partitions. The objects and partitions, totaling $(p+n-1)$ elements, can be permuted in $(p+n-1)!$ ways. The objects alone can be permuted in $p!$ ways, while the partitions alone can be permuted in $(n-1)!$ ways. Since the permutation of the last two types do not give rise to distinct distributions, the number of distribution is

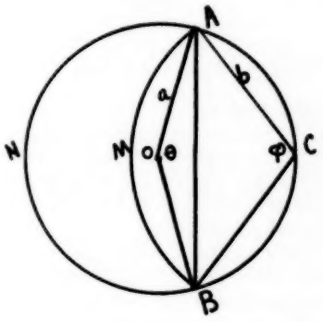
$$\frac{(p+n-1)!}{p!(n-1)} = {}_{p+n-1}C_p$$

EDITORS NOTE: References to this problem are: Chrystal, "Text Book of Algebra," pp. 10–12, 1931; A Treatise on Algebra, C. Smith, pp. 289, 352–3; Hall and Knight," Higher Algebra" 4th edition, Ch. XIV.

Solutions were also offered by Fred Marer, Sidney Cabin, Brooklyn, N. Y., O. L. Dunn, Vincennes, Ind., Charles W. Trigg, Los Angeles, John N. Meighan, Harpers Ferry, W. Va. and the proposer.

1584. *Proposed by Clarence J. Leonard, Detroit.*

A circle has a radius of one inch. Find the radius of a second circle having its center on the circumference of the first circle and cutting off one half of its area.



Solution by Boris Garfinkel, Buffalo, N. Y.

Area of segment ABC = sector AOB − triangle $AOB = \frac{1}{2}a^2(\theta - \sin\theta)$

Likewise, area of segment $ABM = \frac{1}{2}b^2(\phi - \sin\phi)$

Therefore, area $AMBN = A = \pi a^2 - \{\frac{1}{2}a^2(\theta - \sin\theta) + \frac{1}{2}b^2(\phi - \sin\phi)\}$

Eliminating θ and b by means of the relations of the figure:

$$\theta = 2\pi - 2\phi$$

$$b = 2a\cos\tfrac{1}{2}\phi$$

gives

$$A = a^2\{\phi - \tfrac{1}{2}\sin 2\phi - 2\phi\cos^2\tfrac{1}{2}\phi + 2\cos^2\tfrac{1}{2}\phi\sin\phi\}$$

Simplifying by means of identity; $2\cos^2\frac{1}{2}\phi = 1 + \cos\phi$

$$A = a^2(\sin\phi - \phi\cos\phi)$$

By the conditions of the problem $A = \frac{1}{2}\pi a^2$

Therefore $\sin\phi - \phi\cos\phi = \frac{1}{2}\pi = 1.5708$

Solution by approximation yields

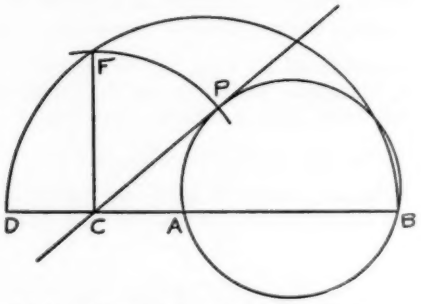
$$\phi = 109°11'$$

$$b = 2a\cos 54°36' = 1.159a = 1.159 \text{ inches}$$

Solutions were also offered by O. L. Dunn, Vincennes, Ind., W. R. Warne, Wm. E. Brooke, University of Minn., John N. Meighan, Harpers Ferry, W. Va., Sidney Cabin, Brooklyn, N. Y., Charles W. Trigg, Los Angeles, Garland D. Kyle, Knoxville, Tenn.

1585. *Proposed by Cecil B. Read, Wichita, Kansas*

Find, by plane geometry, a point in a given straight line at which two given points on the same side of the line subtend the greatest angle.



Solution by Charles W. Trigg, Los Angeles

This problem is a slight variant of 1567. Let the given points be A and B. In any member of the family of circles on AB as chord, the inscribed angle will be constant. This angle decreases as the radius of the variable circle of the family increases. Hence the maximum angle will be that inscribed in the member-circle which is tangent to the given line. The point of tangency is the required point.

To locate this point extend BA to meet the given line at C and further extend it to D so that $DC = CA$. On DB as diameter describe a semicircle, and erect a perpendicular to DB at C meeting the circle at F. With C as center and CF as radius describe arc meeting the given line at P. $FC = \sqrt{DC \cdot CB} = PC = 1\sqrt{CA \cdot CB}$, hence PC will be tangent to the member-circle, and P is the required point.

Solutions were also offered by Sidney Cabin, Brooklyn, N. Y., Winfield M. Sides, Andover, Mass., Garland D. Kyle, Knoxville, Tenn., M. Kirk, West Chester, Pa., Cecil Leith, Scituate, Mass., Kenneth P. Kidd, Gainesville, Fla., O. L. Dunn, Vincennes, Ind., Fred A. Miller, Newell, W. Va., Walter R. Warne, Ralph Brown, Long Island, N. Y., John N. Meighan, Harpers Ferry, W. Va., and Fred Marer.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1574. *Alvin Mars, Abraham Lincoln H. S., Brooklyn, N. Y.*

1580, 1585. *Alvin Mars and Sanford Glassman, Abraham Lincoln High School, Brooklyn, Dominic Paolucci, Hutchinson-Central H. S., Buffalo, N. Y., Bernice Bereskin, Central H. S., Sioux City, Iowa, Muriel Thompson, Los Angeles.*

1583. *Cecil Leith, Scituate U. S., Scituate, Mass.*

PROBLEMS FOR SOLUTION

1598. *Proposed by Cecil B. Read University of Wichita*

Solve completely for x and y:

$$(x+y)(xy+1)=18xy$$
$$(x^2+y^2)(x^2y^2+1)=208x^2y^2$$

1599. *Proposed by Walter R. Warne, Minneapolis*

A and B agree to reap a field in 7 days for \$60. After working together for 5 days they call in C to finish the job in the 7 days. As a result A receives \$4 5/7 less and B \$6 2/7 less than originally planned. In what time could each do the work?

1600. *Proposed by William Taylor, Port Arthur, Texas*

Construct a triangle, given the perimeter, the altitude to the base, and the exradius relative to the base.

1601. *Proposed by John N. Meighan, Storer College, Harpers Ferry, W. Va.*

AB and AD are lines tangent to circle O at B and D respectively. C is the mid-point of line segment BD. Find the locus of point C as A moves on a straight line which does not intersect circle O.

1602. *Proposed by Norman Anning, Ann Arbor, Michigan*

Show that nothing beyond the properties of similar triangles is necessary for establishing the "intercept" form of the equation of the plane:

$$(x/a)+(y/b)+(z/c)=1.$$

1603. *Proposed by Charles P. Louthan, Columbus*

Given a triangle ABC with D and E on sides BA and BC respectively. If DE is the shortest line dividing the triangle into two equivalent parts. Calculate BE and BD in terms of a and b where $a=BA$, $b=BC$.

SCIENCE QUESTIONS

March, 1939

Conducted by Franklin T. Jones

Questions for discussion, examination papers, disputed points may be submitted to this department. They will be published together with discussion.

Please let us know what you are working on. It will be helpful to pass the information along.

Send in your "Do You Know the Answer?" Questions.

Please send copies of tests and examinations to Franklin T. Jones, 10109 Wilbur Avenue, S.E., Cleveland, Ohio.

GQRA—NEW MEMBERS

261. Kenneth G. Peterson, Northfield, Minn.
262. Philip B. Sharpe, Science Supervisor, Greenwich, N.Y.
263. Milton Stitzel, Alfred, N.Y.

JOIN THE GQRA

By proposing a question or sending in an answer.
Both pupils and teachers are eligible.

DO YOU KNOW THE ANSWERS?

(You are invited to submit questions for this section.)

31. How add *two* figures to 41 and have a number less than 41?
32. What and where is a "reversing falls"—a falls in one direction one part of the day and the reverse another part?
33. What is a "fur-bearing" fish?
34. Who has ever seen a ground hog on February 2?
35. What is "voder"? (Hint—Read *Life* for Jan. 30, 1939).

Answers to 21 to 25, January, 1939

21. *Skidding*—On a clean dry pavement your tires exert a very strong push. It is this push that moves your car forward. On a wet pavement the traction of the wheels becomes unequal and the car goes sideways as well as forward.
22. *Singing wires*—Pluck a stretched string or wire and you get a musical note if the wire is tight enough. Cold weather tightens the telegraph wires and the wind "plucks" the string.
23. *Rubber dress-suit*—Akron, the Rubber City, had a fancy dress ball. "From the B. F. Goodrich Co. came five executives costumed in formal and semi-formal evening clothes, first ever tailored from the company's new contribution to the plastics—made of *Koroseal.*"
24. "Soilless culture"—Have you tried it?
25. Nicotine is almost as poisonous as prussic acid. "It takes about one-sixth of a drop of nicotine (about 11 milligrams) to kill a cat or rabbit." Humans require 60 to 120 milligrams—one to two drops of nicotine.

DONT BURN YOURSELF

852. *Proposed by Kenneth G. Peterson, Northfield, Minnesota (Elected to the GQRA, No. 261)*

As a stimulant for actual teaching ideas, I have been studying your Science Problem Department, and I wish to present an idea.

You may think that boiling water is hot, but I can hold on my hand—without any protection from the metal—a boiling teakettle immediately after lifting it from a heat source.

My explanation is that the violently boiling water causes convection currents. When the kettle is lifted from the heat source, those currents continue (inertia of water). As the water passes across the bottom of the container, it takes up the heat remaining in the metal where the hand is touching, thus "cooling" it. As soon as the water ceases boiling, the bottom of the kettle will become hot again, so don't hold it too long However, as long as it is boiling, it is only warm to the touch.

Will you ask your readers for their explanation of this "hot stuff"?

A CAR IS LIKE A CAT

848. *Answer by Milton Stetzel, Alfred, N.Y. (Elected to the GQRA, No. 263)*

I wish to submit the following answer to question 848 under science, A Car is Like a Cat. I am a student at Alfred University and expect to go out teaching General Science next September. I would also like this answer to qualify me for membership in the GQRA club.

The reason for the force increasing as it does, as the car increases in speed from 25, to 50, to 75, with an increase of 4, and 9 times in force due to the formula for Kinetic Energy. $KE = \frac{1}{2}MV^2$. Since M, the mass is

a constant we can eliminate it and say $KE = \frac{1}{2}V^2$, which shows us that the force will increase proportionally to the velocity squared. Therefore $\frac{1}{2}50^2$ equals 4 times $\frac{1}{2}25^2$, and similarly $\frac{1}{2}75^2$ equals 9 times $\frac{1}{2}25^2$. The reason for using KE is that the body is in motion and all bodies in motion possess KE which is equal to the force of the body.

TEST IN SOUND—CONCLUDED

852. *Proposed by H. Emmett Brown, GQRA, No. 255, Lincoln School, Teachers College, Columbia University.*

TEACHERS: *Please time yourself on this entire test and send in your results. Time your best pupil at the appropriate time and send in your result.*

(Continued from January and February, 1939)

40. A certain theater is found to be quite unsatisfactory for the production of plays in that there is a considerable confusion of sounds when performances are given. Check the statements that are true in this situation.
    a. Conditions are worse when the theater is filled with people that when it is empty ..... ( ) a.
    b. Sound will travel more rapidly when the theater is heated than when it is empty and cold ..... ( ) b.
    c. There is too much reverberation ..... ( ) c.
    d. The owner should place material round the walls that will reflect sound more completely so that sound will not be lost by absorption ..... ( ) d.
    e. The owner should endeavor to establish as many places where there are distinct sound foci as is possible ..... ( ) e.
    f. He should place material that has a high absorption coefficient on the walls ..... ( ) f.

    Completion items (g and h)

    g. The first authority in the U. S. in the field of applied science involved in this matter was g _____ g.
    h. h is the name of the branch of applied science _____ h.
41. A given closed pipe strongly resonates to a tuning fork when it is in air at 0°C. (32°F.). If the temperature of the pipe and its surroundings become 25°C., then in order to have maximum resonance the length of the pipe:
    a. needs to be slightly lengthened ..... ( ) a.
    b. should be left unchanged ..... ( ) b.
    c. needs to be slightly shortened ..... ( ) c.

    Assumptions which you needed to make in determining the answer to the above questions are:

    d. The pipe itself does not expand with heat ..... ( ) d.
    e. The vibration rate of the fork is very nearly the same in the two cases ..... ( ) e.
    f. The correction for the diameter of the tube is, in this case, so small as to be negligible ..... ( ) f.
    g. The expansion of the pipe with the rise in temperature is small in comparison with the increase in the speed of sound occasioned by the same temperature rise ..... ( ) g.
    h. The fork is made of steel ..... ( ) h.
42. A phonograph record is played by an electric pick-up and amplifying system. The first time the record is played through, the volume is kept at approximately that at which the record was recorded. The second time through, the record is played very softly, so softly that

it is barely audible to a listener at a distance of three feet from the speaker. As compared with the first playing the second playing will seem:

a. softer, but otherwise unchanged ( ) a.
b. softer, with a loss of some of the high notes only ( ) b.
c. softer, but with a loss of some of the lower notes, only ( ) c.
d. softer, but with the loss of some of both high and low notes ( ) d.

Check the statements that help you to explain the effect noted above.

e. High notes travel faster than low notes ( ) e.
f. Low notes are more readily absorbed by air than are high notes ( ) f.
g. Any difference is due to defects in the reproducing mechanism ( ) g.
h. More energy is required to produce an audible sound with low notes than with frequencies around 2000 v.p.s. ( ) h.
i. More energy is required to produce an audible sound with frequencies around 2000 v.p.s. than with frequencies around 8000 v.p.s. ( ) i.
j. Many fundamentals would not be reproduced the second time that are reproduced the first time ( ) j.
k. A certain minimum amount of energy must be present in a sound in order to set the fibers of the cochlea into vibration ( ) k.

43. Two sounds of slightly different pitch are judged to be of equal loudness by a number of people of normal hearing. Assume that their judgment was correct. Mark statements a to h with the following code:

T—Those statements that are true.
U—Those statements that might be true, or which probably are true, but of which you cannot be sure.
X—Those statements that are surely false.

a. The amplitudes of both waves are the same ( ) a.
b. The energy content of both waves might be measured in calories ( ) b.
c. The note of higher pitch has the higher frequency ( ) c.
d. The energy content of both waves is the same ( ) d.
e. The velocity of the higher note in air is greater than that of the lower note ( ) e.
f. The two sounds, if not pure, have approximately the same number of overtones ( ) f.
g. If the amplitude of both waves is the same, and if the lower note is a pure fundamental, then the other note is also a pure fundamental ( ) g.
h. It would be possible to tell which of the notes contained the greater number of prominent overtones by the use of Helmholtz resonators ( ) h.

44. In a laboratory experiment, the speed of sound in steel and also in lead are determined. Assuming that the results are accurate, the experimenter found that:

a. Sound travels faster in steel ( ) a.
b. Sound travels faster in lead ( ) b.

Mark the following statements, in an attempt to explain the results of the experiment. Use the following code:

T—True and needed in the explanation of the results obtained.

U—True, or possibly true, but not needed in the explanation.
X—False statements.

c. Steel is more elastic than lead..... ( ) c.
d. The temperature of the steel was greater than the temperature of the lead..... ( ) d.
e. The velocity of sound in a given medium varies inversely as the square root of the elasticity of the medium..... ( ) e.
f. Steel is more dense than lead..... ( ) f.
g. The velocity of sound in a given medium varies inversely as the square root of the density of the medium..... ( ) g.
h. Steel is more homogeneous than lead..... ( ) h.
i. Steel is more easily oxidized than is lead..... ( ) i.
j. $V = \sqrt{\frac{D}{E}}$..... ( ) j.

BOOKS AND PAMPHLETS RECEIVED

College Algebra, by Louis J. Rouse, Assistant Professor of Mathematics, University of Michigan. Second Edition. Cloth. Pages xiii+462. 13×19 cm. 1939. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $2.25.

Trigonometry with Tables, by Howard K Hughes, Assistant Professor of Mathematics, Purdue University, Lafayette, Indiana, and Glen T. Miller, Instructor in Mathematics, Purdue University, Lafayette, Indiana. Cloth. Pages viii+189+79. 13.5×21.5 cm. 1938. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $2.00.

America Begins Again, by Katherine Glover. Cloth. Pages xv+382. 13.5×20.5 cm. 1939. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $1.76.

Mathematical Adventures, by Fletcher Durell. Cloth. 157 pages. 13×20 cm. 1938. Bruce Humphries, Inc., 306 Stuart Street, Boston, Mass. Price $2.00.

Physics, A Textbook for Colleges, by Oscar M. Stewart, Professor of Physics, University of Missouri, Columbia, Missouri. Third Edition. Cloth. Pages x+750. 15×23.5 cm. 1939. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $4.00.

Third Digest of Investigations in the Teaching of Science, by Francis D. Curtis, Professor of Secondary Education and of the Teaching of Science, University of Michigan, Ann Arbor, Michigan. Cloth. Pages xvii+419. 13×19.5 cm. 1939. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $3.50.

Your Automobile and You, by Roy A. Welday, Instructor in Physics and Automobile Driving, Scott High School, Toledo, Ohio. Cloth. Pages xiii+251. 12×19 cm. 1938. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price 88 cents.

Investigations of Vocabulary in Textbooks of Science for Secondary Schools, by Francis D. Curtis, Professor of Secondary Education and of the Teaching of Science, University of Michigan, Ann Arbor, Michigan. Cloth. Pages viii+127. 15×23 cm. 1938. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $1.40.

The Contribution of Generalization to the Learning of the Addition Facts, Teachers College, Columbia University Contributions to Education, No. 763, by C. L. Thiele, Ph.D. Cloth. Pages viii+84. 15×23 cm. 1938.

Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.60.

A Study of the Possibilities of Graphs as a Means of Instruction in the First Four Grades of the Elementary School, Teachers College, Columbia University Contributions to Education, No. 745, by Ruth G. Strickland, Ph.D. Cloth. Pages viii+172. 15×23 cm. 1938. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.85.

General and Inorganic Chemistry, by Frederick C. Irwin, Professor of Chemistry, Wayne University, Detroit Michigan, and G. Ray Sherwood, Assistant Professor of Chemistry, Wayne University, Detroit, Michigan. Cloth. Pages x+582. 14×21.5 cm. 1939. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $3.50.

Radio Trouble-Shooter's Handbook, by Alfred A. Ghirardi, author of "The Radio Physics Course," "Modern Radio Servicing," etc. Cloth. Pages x+518. 21.5×28 cm. 1939. Radio and Technical Publishing Company, 45 Astor Place, New York, N. Y. Price $3.00.

Proceedings of the Thirty-Second Annual Convention of The Association of Life Insurance Presidents Held in the Waldorf-Astoria. Paper. 239 pages. 13×22.5 cm. 1938. The Association of Life Insurance Presidents, 165 Broadway, New York, N. Y.

Vocational Education, by John Dale Russell and Associates. Prepared for The Advisory Committee on Education. Staff Study Number 8. Paper. Pages x+325. 14.5×23 cm. 1938. Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Price 40 cents.

Inventory, An Appraisal of Results of the Works Progress Administration, Harry L. Hopkins, Administrator. Paper 100 pages. 22.5×30 cm. 1938. Works Progress Administration, Walker-Johnson Building, 1734 New York Avenue, N.W., Washington, D. C. Price 30 cents.

Pennsylvania Program of Extension Education. Lester K. Ade, Superintendent of Public Instruction. Bulletin 292. 83 pages. 15×23 cm. 1938. Commonwealth of Pennsylvania, Department of Public Instruction, Harrisburg, Pa.

Publications Available for Distribution. Lester K. Ade, Superintendent of Public Instruction. Bulletin 7. 23 pages. 15×23 cm. 1939. Commonwealth of Pennsylvania, Department of Public Instruction, Harrisburg, Pa.

The Non-Technical Aspects of Engineering Education, A Bibliography Compiled by The Cooper Union Library. November 1938. 10 pages. 15×23 cm. The Cooper Union, for the Advancement of Science and Art, New York, N. Y.

BOOK REVIEWS

Erratum: In the review in the January issue of *Plane Geometry* by George T. Major the address of the Phillips Exeter Academy was given as Andover, Massachusetts instead of the correct address: Exeter, New Hampshire.

A Manual for the Biology Laboratory, by Perry D. Strausbaugh, Professor of Botany, West Virginia University, and Bernal R. Weimer, Professor of Biology, Bethany College, West Virginia. Paper. Pages ix+183. 21.5×28 cm. 1938. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $1.75.

The authors' idea of the true purpose of laboratory work in a course in science is well expressed in their excellent, *Foreword to the Student*. With their objectives most teachers will probably agree. As to the choice of material and methods employed there will be some disagreement.

The first part of the manual consists of 47 two-column pages of printed directions arranged by topics to agree in general with the recent textbook by the same authors. This is followed by about 70 work sheets, perforated for removal from the manual. The units are presented in the following order: The Microscope, Plant Structures (angiosperms), Food Manufacture, Digestion, Food Transfer in Animals, Respiration, Excretion, Irritability, Reproduction and Development, Homology, Analogy, Muscles (frog), Heredity, The Animal Kingdom (taxonomy), The Plant Kingdom (taxonomy).

A good many of the experiments and observations are labeled "Optional"; others are marked "Demonstration" or "Instructor's experiment." The exercises are well worked out, and in grade of difficulty are quite comparable to many used in manuals of introductory botany and zoology. On the much mooted question as to whether to require students to make original drawings or to furnish them with ready made drawings for labeling, the authors have struck what may be a happy compromise. Some of the more difficult drawings, such as the cross section of a root and the circulatory system of the frog, are already drawn and merely require labeling; others, such as the cross section of Hydra, are partly drawn but require completion and labeling; while others, such as the parts of a flower, are to be drawn in full. The quality of the drawings and the paper on which they are made is very good.

The manual is bound with a spiral band which permits it to lie perfectly flat when opened.

Those who are giving a course in laboratory college biology will be interested in examining this manual.

EDWARD C. COLIN, Wilson Junior College, Chicago

General Biology, A Textbook for College Students, by Perry D. Strausbaugh, Professor of Botany, West Virginia, and Bernal R. Weimer, Professor of Biology, Bethany College, West Virginia. Cloth. Pages xi+555. 14.5× 23 cm. 1938. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $3.75.

This book is an extremely interesting example of what can be done with color printing. There are thirteen full page colored plates, eight of them in four colors. It is surprising how much more interesting and effective the figures become with the addition of even one color. It seems safe to predict that we have seen merely the beginning of the use of color in text books of biology. The book is also unusual in the number of excellent line drawings, many of which are either original or redrawn.

There are seventeen chapters, with the topics discussed in the following order: origin and nature of life, including the cell; five chapters on metabolism of plants and animals; irritability and adjustments: growth and reproduction; heredity and eugenics; principles of taxonomy; the invertebrates; the vertebrates; two chapters on the plant phyla; the relation of organisms to their environment; evolution; and the relation of biology to other sciences. On the question of sequence and emphasis it is of course not to be expected that any two biologists will ever agree, and this is one more illustration of that fact. The last textbook in college biology reviewed by the writer began with ecology and taxonomy. On the question of emphasis it seems to the reviewer that there is some unnecessary duplication in the present book in the detailed treatment of plants. There are full page figures and discussion of the life cycles of the following: the seed plant, wheat rust, Marchantia, moss, fern, Equisetum, Lycopodium, and Selaginella. Reproduction in the pine is also discussed by use of detailed figures. The technical terminology on plants might well be reduced, and

other topics such as plant hormones added. The discussion of evolution could be improved by the inclusion of some of the important new material from genetics such as one finds in Dobzhansky's "Genetics and the Origin of Species."

The style of the book is simple and clear. There is an unusually complete index covering thirty pages. As a sample of the printer's art we have here a book worthy of the highest praise.

The authors have prepared a laboratory manual designed to accompany the text.

EDWARD C. COLIN, Wilson Junior College, Chicago

Our Physical World, by Charles F. Eckels, Chalmer B. Shaver, and Bailey W. Howard of the Department of Physical Science, Pasadena Junior College, Pasadena, California. Cloth. Pages xi+801. 13.5×20.5 cm. 1938. Benj. H. Sanborn and Company, 131 Clarendon Street, Boston, Mass. Price $2.20.

Our Physical World is quite evidently a book that has grown up in the science classroom. The authors are teachers of the students for whom it was written. The language used is the language these students understand; many of the topics discussed are the questions students interested in science will ask. There is also a systematic attempt made to stimulate the interest of pupils who have little knowledge of or interest in science. Each topic is approached through familiar illustrations or situations made interesting by brief historical narratives of scientific events, by use of pictures and diagrams—by something which at once catches the attention and makes one read farther. The book is replete with instructional aids in the form of references to books and magazines of popular and fundamental science, films, suggestions for individual experimentation, demonstration experiments, questions, etc.

The subject matter is mainly physics, with less space given to topics usually considered chemistry, and still less emphasis on topics from astronomy and geology. The treatment is so completely descriptive that a teacher who has been engaged in preparing students for engineering, medicine, and other scientific occupations gets the impression that it is a book about science rather than a textbook of science. This feeling is no doubt a compliment rather than a criticism when account is taken of the real aim of the physical science survey course and of its student body. A pupil who acquired an interest in any subject will become a student of the subject. This seems to be the philosophy of the authors and they have provided sufficient guidance for this future study.

G. W. W.

An Orientation in Science, by Ten Members of the University of Rochester Faculty. C. W. Watkeys, Chief Editor. First Edition. Cloth. Pages x+560. 14.5×23 cm. 1938. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $3.50.

This is a textbook for orientation courses in freshman college science. No other text that has been brought to our attention covers such an extensive subject matter field. The chapter headings indicate its breadth: Astronomy, Geology (Part I), Chemistry (Part I), Physics, Chemistry (Part II), Geology (Part II), Biology, Paleontology, Physiology, Bacteriology, Psychology, Mathematics, Scientific Method. Each science is discussed by a specialist in that field. While a uniform plan has been followed by all authors and an excellent job of editing has prevented duplication and repetition in overlapping fields, there is no real integration of subject matter. In going from one chapter to the next the reader is quite conscious of passing from one realm into another.

Some of the chapters assume a vast amount of fundamental knowledge. This is especially true of the chapter on physics where so much basic physics is assumed that the "mine run" of high school graduates will at best get only vague ideas of the epoch-making experiments described and the stupendous developments resulting from them. The reviewer is inclined to believe that when a college freshman he would not have made much progress in the chapter on mathematics without considerable help and would probably have given up in despair and disgust. Other chapters are in the main on the level of average first year students; they are interesting, stimulating, challenging. Throughout the text is authentic. When presented to superior students by skilled instructors it will no doubt promote the accepted aims of science education.

G. W. W.

Earth Science, a Physiography, by Gustav L. Fletcher, Chairman, Department of Physical Science, James Monroe High School, New York City; Instructor of Geology, Hunter College (Extension Sessions). Cloth. Pages v+568. 1938. D. C. Heath and Co., Boston, Mass., Price $2.20.

This text, based on New Physiography by Arey, Clendenin, Bryant and Morrey, contains 33 chapters, 19 of which deal with the earth and the agents shaping its surface; 10 with the presentation of such topics as Latitude and Longitude, the Solar System, Air, Winds, Light, Weather and Climate; 3 with the Sea, Shore Lines and Harbors. Each chapter has a Completion Summary and Exercises for review. The General Review Questions at the end of the book are adapted from the New York State Regents Examinations. The text is enriched with 343 illustrations, maps, diagrams and photographs.

VILLA B. SMITH

Introductory Biology, by Harry L. Andrews, Nellie J. Basma, E. C. Colin, R. Clark Gilman, S. W. Howe, H. E. Nelson, Jesse F. Schuett, Andrew Stauffer, John P. Wessel of the Municipal Junior Colleges Herzl, Wilson and Wright of the city of Chicago, Ill. Paper, planographed. Pages iii +313. Size 15×22cm. 100 figures several from a photo base. Published by the authors. 1936–1938.

This is a syllabus for the junior college level. It is divided into 4 units, each unit is divided into several topics. Each topic is completely outlined in detail. The units are titled as follows: 1—Energy relations in living things. 2—Reproduction and development. 3—Underlying principles of biotic relationships. 4—Origin and evolution of life. Each topic has a reference list adequately covering the topic. Ordinarily a syllabus isn't expected to carry figures or illustrations but this book has several which could be used as good references. Although in the preface, the authors modestly hint that the book is not a substitute for a reference, this book could serve very well as a quick reference for biologic principles.

Unit 4 is especially of value to the High School teacher. This unit starts off the matter of evolution so nicely that the teacher should have little trouble interpreting it to her students.

A. G. ZANDER

An Introduction to Riemannian Geometry and the Tensor Calculus, by C. E. Weatherburn. Pages xi+191. 13.5×21.5 cm. 1938. Cambridge University Press or the Macmillan Company, New York, Price $3.75.

This book is designed to bridge the gap between differential geometry of Euclidian Space and the more advanced differential geometry of generalized space. The first chapter is devoted to some preliminary topics

such as determinants, differentiation of determinants, matrices, linear transformations, quadratic forms, and differential equations, which are to be used in the sequel.

The headings of the remaining chapters are as follows: II. Coordinates, Vectors, Tensors; III. Riemannian Metric; IV. Christoffel's Three-Index Symbols, Covariant Differentiation; V. Curvature of a Curve, Geodesics, Parallelism of Vectors; VI. Congruences and Orthogonal Ennuples; VII. Riemann Symbols, Curvature of a Riemannian Space; VIII. Hypersurfaces; IX. Hypersurfaces in Euclidian Space; X. Subspaces of a Riemannian Space.

The book will be of special interest to those who wish to study the mathematical treatment of Relativity.

J. M. KINNEY

Essentials of Biology, by W. H. D. Meier, Head of the Department of Biology, State Teachers College, Framingham, Massachusetts, and Louis Meier Shoemaker, Assistant Professor of Science, State Teachers College, Trenton, New Jersey. Cloth. Pages vii+725. 12.5×19.5 cm. 1938. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $1.80.

The new and enlarged edition of *Essentials of Biology* contains all the materials of the original edition. It provides a balanced treatment of the principles underlying plant and animal life.

New materials have been added to the following units: Classification of Plants, Plant Culture, Soil Erosion, Injurious Plants and Their Control, and Plants and Animals of the Past. These changes and additions have definitely added to the value of the book.

The subject matter is cleverly presented in eleven related units, which may be studied in an order to suit the seasonal requirements. Each unit begins with the study of the student's environment and leads him gradually from familiar to new ideas.

The book is well organized and the information is accurate and modern.

J. P. WESSEL, Wright Junior College, Chicago

New Introduction to Biology, by Alfred C. Kinsey, Professor of Zoology, Indiana University. Revised. Cloth. Pages xv+845. 13×19.5 cm. 1938. J. B. Lippincott Company, 220 No. Michigan Avenue, Chicago, Ill. Price $1.76.

Professor Kinsey has undoubtedly devoted a large part of his life trying to understand the kind of biology and the method of presentation best suited to the needs of the high school student. In this he has met with an unusual degree of success.

This book presents a unified and balanced picture of the biological world. Its objective seems to be to help human beings to understand the behavior of living organisms, and the relations which exist among those organisms.

Basic principles, rather than unrelated facts, are emphasized. Professor Kinsey is ever mindful of the concepts which a pupil ought to be expected to keep and use as long as he lives.

The book is written in a clear, forceful, and interesting style. It is profusely and beautifully illustrated and throughout.

J. P. WESSEL, Wright Junior College, Chicago

Descriptive Geometry, by Floyd A. Smutz, Professor of Engineering Drawing and Descriptive Geometry, Kansas State College of Agriculture and Applied Science, and Randolph F. Gingrich, Associate Professor of

Machine Design, Kansas State College of Agriculture and Applied Science. Second Edition. Cloth. Pages x+227. 15×23 cm. 1938. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $2.50.

The second and revised edition of this text by Smutz and Gingrich, with its expanded sections and general rearrangement of some of the material, marks another valuable addition to the works in this field. The authors have proceeded with the intention of making the subject one of interest and practical value to the student rather than attempting to offer new material on the purely abstract phases of descriptive geometry. Consequently, emphasis has been placed upon the treating of the subject as a science of graphics with valuable and direct applications to the work of the engineer. To this end an early introduction to drafting room methods of solution is made with a result that a very large proportion of the problems are solved by the direct projection or auxiliary plane method. Abstractions and the use of the conventional method of solution, while minimized, are not entirely overlooked, for their value is recognized in the stressing of fundamentals.

Analysis and construction explanatory matter are very clearly set forth and consistently followed throughout, with an abundance of illustrations and a great variety of exercises and problems. Many interesting and valuable practical application problems are also introduced.

The typography is very clear and attractive with perhaps the only jarring note in the format being due to the lack of uniformity in scale of some of the figures and lack of sharpness of line of a few of the cuts for the illustrations.

H. D. ROLLER, Wilson Junior College, Chicago

MOTION PICTURE REVIEWS

The River. U. S. Government Documentary Film. Not yet available for school use but, according to recent notices, soon to be made so. To be released on 16 mm. Sound on film.

I. The Story of the Film

The River is a documentary film produced for the U. S. Dept. of Agriculture by Pare Lorentz who also produced *The Plow that Broke the Plains*. The tragic biography of the Mississippi River unfolds in sequences of brilliant photography. Opening scenes stress the origins of the river and its tributaries. From the Rockies to the Alleghenies, from Minnesota to the Gulf flow streams "carrying every drop of water, that flows down two-thirds of the continent."

The film presents a story of heedless exploitation of the great valley, of wasteful development unguided by any foresight of ultimate results. Over-cropping of uplands for King Cotton and for corn and wheat left wornout and eroded soil—and people moved on. In order to make more land available a dangerous river was imprisoned in a thousand miles of dykes. After the flames of civil war had seared the land there was a great movement to new land. There was timber in the North! From the hills of Minnesota and Wisconsin flowed rivers of logs, leaving the land barren and desolate. Iron and coal added to the growth of industrial cities along the river. "We built a hundred cities and a thousand towns—But at what a cost!"

The results of short-sighted exploitation are reflected in the lives of the people. Through the valley destructive floods sweep repeatedly, bringing

acute suffering—hundreds dead, hundreds of thousands homeless. On the uplands where heavy crops have sapped the soil and where erosion has carried away the top soil chronic suffering increases. "Poor land makes poor people. Poor people make poor land." A large portion of the new generation is "ill-clad, ill-housed, and ill-fed—and in the greatest river valley in the world."

After the serious situation is presented there is a change of tempo. If man has taken the valley apart he may also put it back together again. Regional planning is proposed as one attack upon a problem of this magnitude. The efforts of the TVA are to this end. Great dams for the control and conservation of water, reforestation, soil conservation through scientific tillage, improvement of living conditions, and great electrical plants at the dams to produce power—"Power enough to make the river work!"

II. Criticism of the Film as a Teaching Aid.

The film makes valuable contributions to the learning experiences of secondary school pupils, from the junior high school upward. It may be used to great advantage in either social studies or science classes. While it is an excellent vehicle for the presentation of the whole problem, for developing a powerful impression of the serious problem facing our nation today, it also presents a wealth of detailed information. The film develops a better understanding of the problems of conservation for intelligent use, proper cropping methods, transportation developments, flood control, long-range planning, and of the relationship of people to the soil. As a documentary film it is relatively free from propaganda. The serious problem is presented as the outgrowth of conditions as they were—there is no attempt to place the blame. Conservation methods now available, as presented in the closing sequences of the TVA, are reassuring after the rather depressing story told by the earlier part of the film.

III. Technical Qualities of the Film.

The whole story is told in a most impressive manner. One is carried along by the flow of excellent photography, impressive narrative, and effective music. This is one of the few educational films to which the music makes a genuine contribution. Often one is stirred by the poetic cadence of the story, "Down the White—, Down the Cumberland—, Down the Kaw and Kaskaskia, the Red and the Yazoo,—" At other times one is impressed by the dramatic quality of the voice, "River rising. Helena: river rising. Cairo: river rising." *The River* and the problems it presents will not soon be forgotten.

Rating:

1. Age level: Secondary school and upward
2. Quality of photography: Excellent
3. Selection of scenes: Excellent
4. Sound track: Narration excellent in both content and delivery. Muscial background most effective.

Conservation of Natural Resources. Distributed by Erpi Classroom Films Inc., 35–11 Thirty-fifth Avenue, Long Island City, N. Y. 1 reel, 16 mm. Sound on film. For sale.

Story of Film: Scenes of forest fires are followed by some of the various means used to control and prevent these menaces such as, a fire warden making observations, the cutting of cleared lanes, and the cleaning out of the underbrush.

The film then shows the use of some of the wood that might have been destroyed in fires, and the replanting of forest lands.

The film then shifts to erosion, showing sketchily how running water gullies unprotected, cultivated land. Perhaps the best sequence is that which deals with the use of dams to prevent floods and control erosion. This is done by the building of retention dams in small gullies, by introducing a beaver near a stream where a dam is desired, and by the building of large masonry dams.

Contour plowing is shown briefly as a means for preventing erosion, but we see actually neither how the plowing is done, nor how it prevents erosion.

Plowing the west as a cause of dust storms then follows, with some scenes which show the results of dust storms. The extent of the dust bowl is indicated. The return of the land to grass and trees is suggested as a cure for such storms.

The film then takes up oil conservation, shows how oil is wasted directly or through burning when a well is tapped, and mentions some of the by-products of oil, namely, gasoline, fuel oil, lubrication oil, mineral oil, and paraffin with scenes showing the use of these materials.

The final sequences deal with stream pollution by both industrial waste and sewage, showing how stream pollution fouls the water and kills fish. Sewage disposal is suggested as a solution to this problem. The film closes with the suggestion that this procedure will cause the rivers again to run clear, a conclusion which is by no means justified.

Criticism of Film: One has the feeling that this film on conservation attempts to "cover the earth." Though all the scenes are definitely related to conservation, no phase of it is developed adequately to give a sense of comprehension. It is as if the outline of a story were presented, rather than the story itself. One is struck with the contrast between this film and the U. S. Government film, "The River," which so artistically presents the story of the conservation of forests and soils.

The commentary is explicit. This serves somewhat to unify the story.

The sketchiness of the film tends to limit its use. It may be used as an introduction to the study of conservation, or as a suggestive review at the end of such study.

Technical qualities: The film is good technically. The photography is clear, the commentary well spoken, and it is accurate.

Rating:

1. Age level—Useful at all levels.
2. Quality of photography—Good.
3. Selection of scenes—Fair.
4. Spoken commentary—Good.

Reviewing Committee
N. ELDRED BINGHAM
F. T. HOWARD
H. EMMETT BROWN, Chairman

A STUDENT PROJECT

The editor is in receipt of an unusual sample of etching done by Earl Tracey, a student at Orlando (Fla.) Senior High School. The etching was done in the usual way with hydrofluoric acid but the entire figure is made to stand out by (1) the use of bronze paint in the lines, (2) a backing of green paint on the area of the figure, and (3) a field of bronze paint surrounding the figure. Mounted on a wood base the etching becomes a real work of art. Thank you Mr. Tracey.